EFFICIENCY IMPLICATIONS OF CORPORATE DIVERSIFICATION:

EVIDENCE FROM MICRO DATA

by

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CES 06-26　　　November, 2006

Abstract

In this study, we contribute to the ongoing research on the rationales for corporate diversification. Using plant-level data from the U.S. Census Bureau, we examine whether combining several lines of business in one entity leads to increased productive efficiency. Studying the direct effect of diversification on efficiency allows us to discern between two major theories of corporate diversification: the synergy hypothesis and the agency cost hypothesis. To measure productive efficiency, we employ a non-parametric approach—a test based on Varian's Weak Axiom of Profit Maximization (WAPM). This method has several advantages over other conventional measures of productive efficiency. Most importantly, it allows one to perform the efficiency test without relying on assumptions about the functional form of the underlying production function. To the best of our knowledge, this study is the first application of the WAPM test to a large sample of non-financial firms. The study provides evidence that business segments of diversified firms are more efficient compared to single-segment firms in the same industry. This finding suggests that the existence of the so-called 'diversification discount' cannot be explained by efficiency differences between multi-segment and focused firms. Furthermore, more efficient segments tend to be vertically integrated with others segments in the same firm and to have been added through acquisitions rather than grown internally. Overall, the results of this study indicate that corporate diversification is value-enhancing, and that it is not necessarily driven by managers' pursuit of their private benefits.

J.E.L. Classification Codes: D2; D92; G34

Keywords: Restructuring; Diversification; Efficiency

* We thank Shomu Banerjee, Martin Grace, Ufuk Ince, Omesh Kini, James Owers, and Richard Phillips for valuable comments and suggestions. The paper has also benefited from suggestions from seminar participants at San Diego State University, San José State University, and University of St. Thomas. We also thank Susan Chen, Michelle Danis, and Kirk White at the Triangle Census Research Data Center for crucial administrative and data support. Financial support for this study has been provided through the Census Data Fellowship, GSU Dissertation Grant and by the Department of Finance at Georgia State University. In addition, financial support for this research at the Triangle Census Research Data Center from the National Science Foundation (grant award numbers SES-0004322 and ITR-0427889) is gratefully acknowledged. All remaining errors are ours. The research in this paper was conducted while the authors were Special Sworn Status researchers of the U.S. Census Bureau at the Triangle Census Research Data Center. Research results and conclusions expressed are those of the authors and do not necessarily reflect the views of the Census Bureau. This paper has been screened to insure that no confidential data are revealed.

1. Introduction

There is an ongoing spirited debate among scholars and practitioners about the motives for corporate diversification and its consequences for shareholders. In the neoclassical competitive model, firms are assumed to maximize profits and to operate in competitive and frictionless product and capital markets. Under these conditions, there is no apparent reason for multi-business firms to exist. This is because any benefits from having several business segments, such as operating synergies, can be achieved through market contracts. Likewise, financial synergies fail to explain why multi-business firms emerge. Reduction in non-systematic risk can be achieved by shareholders capable of diversifying away the risk costlessly on their own.

Theoretical justification of diversification has evolved along two main rationales. One set of explanations is based on the existence of certain imperfections in the product or capital markets and thus maintains that diversification serves an economic purpose. According to this view, diversification provides various potential benefits, such as reduction in transaction costs (Coase (1937)), creation of internal capital markets (Stein (1997)), greater operating efficiency through economies of scope and scale (Teece (1980)), greater debt capacity (Lewellen (1971)), and lower expected taxes. An alternative explanation relies on the conflict of interest between managers and shareholders, where managers choose to diversify in order to extract private benefits from operating bigger and more complex business entities (Amihud and Lev (1981)).

The purpose of this study is to discern between the two major theories about the motives for corporate diversification: the synergy and agency-cost hypotheses. In doing this, we do not focus on the indirect consequences of diversification, such as its effect on the market value of the firm. Several studies have shown that diversified firms' shares trade at a discount relative to their focused counterparts (e.g., Lang and Stulz (1994) and Berger and Ofek (1995)). However, the existence of the so-called 'diversification discount' does not necessarily imply that diversification *per se* destroys value. First, a growing body of literature ties the finding of the diversification discount to selection biases. These studies argue that the discount may arise not because firms are diversified, but because of certain characteristics inherent in diversified firms. For instance, Graham, Lemmon, and Wolf (2002) and Campa and Kedia (2002) show that firms that diversified had already discounted market values prior to their diversification. One explanation suggested for this is that firms that have initially low market values due to poor investment opportunities tend to diversify into other industries in search of new opportunities. Similarly, several other studies (Chevalier (2004) and Hyland and Diltz (2002)) point to systematic differences in investment patterns between single-segment firms and diversified firms even before their decision to diversify. Second, one needs to ascertain whether the discount is estimated properly. Villalonga (2004), for example, questions the notion of diversification discount by demonstrating that using an alternative to COMPUSTAT data source—the Census' Business Information Tracking Series (BITS)—eliminates the discount. In fact, diversified firms with business units defined according to the BITS data are found to trade at a premium relative to focused firms.

We take a more direct approach to examining the underlying rationale for corporate diversification by studying the effect of diversification on productive efficiency. This study is closely related to Schoar (2002), which compares productivity of plants that are operated by diversified firms to that of plants of focused firms. However, in a departure from Schoar's work (as well as other studies on productive performance, in general) that estimates efficiency using a parametric method, we employ a test based on the Weak Axiom of Profit Maximization (WAPM). The main advantage of using the WAPM test is that, unlike most conventional methods of estimating efficiency, it imposes no functional form on the data. This eliminates the possibility of misspecification of the parametric form of the production function. On the practical side, the WAPM test does not require a large data set in order to give robust results. This test has previously been used to estimate firm efficiency in studies of financial institutions (Hermalin and Wallace (1994)), insurance companies (Garven and Grace (2002)) and farms (Tauer and Stefanides (1998)). However, we believe that ours is the first study to apply the WAPM test to a sample of non-financial firms (other than farms).

Additionally, this non-parametric approach is particularly suitable for the research question studied in this paper. It relies on one of the fundamental principles of economics—the principle of substitution. That is, faced with a feasible set of possibilities, an efficient (profit-maximizing) firm will substitute cheaper inputs for more expensive inputs. One can think of corporate diversification as a way to expand the set of feasible inputs and outputs. With a larger set of possibilities, diversified firms may be better off compared to single-segment firms due to their improved ability to allocate operational resources where they are most valuable. However, whether a firm can take advantage of this potential depends on managerial skills and incentives.

Our primary data sources are the Longitudinal Research Database (LRD) and the Longitudinal Business Database (LBD), which are unpublished micro databases from the Center for Economic Studies at the U.S. Census Bureau. To produce meaningful and unbiased results, the WAPM test requires data on input/output quantities and associated costs. To the best of our knowledge, the LRD is the only source of such detailed information at the plant level for the U.S. manufacturing sector. We use the LBD, which contains firms' industry participation data, to estimate the degree of firm diversification. Using the establishment-level Census data to identify operations of a firm in a particular industry overcomes concerns about the subjectively disaggregated nature of financial data in COMPUSTAT Segment files (Villalonga (2004)).

Our study provides strong evidence that business segments of diversified firms are more efficient compared to single-segment firms in the same industry. This suggests that the diversification discount, should it exist, cannot be explained by efficiency differences between diversified and focused firms. This finding is in line with the 'productivity premium' found in Schoar (2002) and is consistent with the 'diversification premium' obtained by Villalonga (2004) using the Census data. Furthermore, our results indicate that more efficient segments tend to be vertically integrated with other segments in the same firm and to have been added through acquisitions rather than grown internally. We also find that segments with a higher degree of efficiency are more likely to change ownership. More efficient firms tend to be buyers, while less efficient firms tend to be sellers.

Overall, the findings in this study are consistent with the synergy hypothesis, positing that corporate diversification creates value through operating synergies. The study joins a recent stream of research, (such as Campa and Kedia (2002), Schoar (2002), and Villalonga (2004)) that questions the interpretation or existence of the diversification discount.

The remainder of the paper is organized as follows. Section 2 provides a literature review of relevant studies. Section 3 presents the hypotheses to be tested. Data sources are described in Section 4. In Section 5 we describe the variables that are used in the subsequent empirical analysis. Sample description and empirical findings are reported in Section 6. Section 7 concludes the paper.

2. Literature Review

The majority of the existing literature on the subject has based its conclusions about motives for diversification by either examining the wealth effects to firms' decisions to diversify or comparing values of diversified firms to those of their focus counterparts. Former studies have produced mixed results.[1] One set of findings indicates that diversification decreases firm value. Morck, Shleifer, and Vishny (1990) find that during the 1980s, unrelated acquisitions resulted in negative returns to acquiring firms. In accordance with that study, John and Ofek (1995) report that diversified firms experience greater returns when they announce focus-increasing asset sales. On the other hand, Matsusaka (1993) and Hubbard and Palia (1999) find positive returns to announcements of diversifying acquisitions during the 1960s and 1970s. Finally, De (1992) finds no correlation between the degree of focus and excess returns.

Studies that examine values of diversified firms compared to those of focused firms generally find evidence of a significant negative relation between diversification and firm value. For example, Lang and Stulz (1994) report that diversified firms trade at a discount of about eight percent relative to a portfolio of stand-alone firms. Similarly, Berger and Ofek (1995) document that diversified firms are traded at a discount of 13%-15% relative to stand-alone firms over the 1986-1991 period. However, a growing body of recent literature suggests that the so-called 'diversification discount' arises not due to the fact that firms are diversified, but their other characteristics. One reason for the discount might be that diversified firms choose to diversify in certain lines of business (Hyland and Diltz (2002) and Chevalier (1999)). Graham, Lemmon, and Wolf (2002) and Campa and Kedia (2002) question the interpretation of the discount by indicating that firms that diversify had already discounted market value prior to their diversification.

[1] A review of studies on diversification's overall value effect can be found in Comment and Jarrell (1995).

One explanation is that firms that have initially low market values due to poor investment opportunities choose to diversify in search of new opportunities. Based on the risk reduction argument, Mansi and Reeb (2002) also challenge the conventional interpretation of the diversification discount. They argue that risk reducing effects of corporate diversification might actually lead to a decrease in firm value if the firm is leveraged. The premise is that in a contingent claims framework, reducing firm risk affects shareholder value negatively and bondholder value positively.

It is apparent that the evidence provided by the studies that have examined conceivable rationales for diversification by relying on market valuations is inconclusive. Only a handful of studies have taken a different approach to assessing benefits and costs of corporate diversification in a non-financial sector by examining the direct effect of it on productive efficiency. We provide an overview of these studies next.

Lichtenberg (1992b) was first to suggest that diversification may have a direct effect on productivity. The main question of his study is why ownership changes increase productivity. He conjectures that diversification is inversely related to productivity, and ownership changes lead to a reduction in the extent of diversification. The presumption is that the degree of a firm's diversification affects the productivity of its plants. To examine the effect of diversification on productivity, the author uses data on manufacturing plants from the 1980 Annual Survey of Manufactures. The test is based on estimating deviations of plants' productivity in the same industry, measured by the four-digit SIC code. The findings provide evidence that the parent's diversification is negatively related to the productivity of its plants. The author's test of whether ownership changes result in dismantling of the conglomerate firm is based on inspection of changes in the distribution of firms by the number of their segments in Compustat in the second half of the 1980s. He observes that, during the sample period, the mean number of industries per firm declined by 14 percent. Citing high takeover activity in the 1980s, the author speculates that ownership changes are most likely to be responsible for much of the documented reduction in diversification.

Maksimovic and Phillips (2001, 2002) study the impact of productivity on the optimal firm growth and resource allocation across different industries. Maksimovic and Phillips (2002) profit-maximizing model predicts that growth and investment of a diversified firm across its segments are related to its segments' productivity and industry conditions. Firms that are productive in a particular industry have greater opportunity costs of diversifying. Consistent with the model's predictions, the empirical analysis of manufacturing plants from the LRD indicates that plants of focused firms are more productive than those of diversified firms of similar size, except for the smallest size firms. This result is consistent with the finding of a diversification discount. However, examining productive efficiency within a conglomerate, the authors find that larger divisions of conglomerates tend to be more productive than their smaller, peripheral, segments. This finding is consistent with optimal behavior if firms grow more in industries in which they have a comparative advantage. This implies that the diversification discount may not be exclusively due to agency problems. Further, a diversified firm's growth declines in a particular industry if that firm's plants in other industries are more productive. Thus, the authors find no support for the view that diversified firms engage in inefficient cross-subsidization of their less productive segments.

Based on their earlier study, Maksimovic and Phillips (2001) explore sales of individual plants in manufacturing industries. They hypothesize that a positive demand shock in an industry results in gains in value (opportunity costs) from assets for more (less) productive divisions operating in that industry. As a result, during a boom, assets flow from less productive to more productive firms in the industry.[2] The authors find that a plant is more likely to be sold when its productivity decreases, its division productivity decreases, and the selling firm's other divisions have good prospects. They also find that, taking into account changes in productivity of both the purchased and existing assets, overall buyer productivity increases for asset purchases. The results support the hypothesis that there are gains in productivity when assets are redeployed from less productive to more productive firm.

Schoar (2002) contrasts the overall productivity of conglomerates with comparable stand-alone firms, using a sample of LRD plants between 1977 and 1995. In contrast with the finding in Lichtenberg (1992b) and Maksimovic and Phillips (2002) that diversification tend to depress productivity, she reports that plants of diversified firms are

[2] The assumption of decreasing return-to-scale allows less-productive firms to exist in equilibrium.

as much as seven percent more efficient than plants of single-segment firms.[3] However, in the process of becoming more diversified, firms suffer a net reduction in productivity: An increase in productivity of newly-acquired plants does not offset a decrease of productivity of incumbent plants of the same firm. The author concludes that diversified firms enjoy a 'productivity premium' over comparable stand-alone firms. Moreover, the study's findings suggest that although this productivity advantage is dissipative with the firm's each additional diversifying decision, diversified firms still have the productivity advantage in the cross section. Since the results do not conform to the well-established finding of the diversification discount, the author re-calculates the diversification discount based on industry segment information from the LRD. She finds that the discount is about ten percent. This discrepancy could further raise questions regarding the interpretation of the diversification discount or be attributed to some shortcomings in the empirical methodology. With some caution, the author suggests that the discrepancy might be partially explained by the fact that diversified firms disburse a larger fraction of their revenues in the form of higher wages than focused firms. Therefore, the existence of the full amount of the diversification discount remains unexplained.

Overall, the research that examines the impact of diversification on productive efficiency has produced mixed results. In regards to methodology, the extant studies primarily use the Total Productivity Factor to estimate efficiency. In this study we take a different approach and employ the Weak Axiom of Profit Maximization test to measure efficiency. This is a non-parametric test, and therefore it eliminates the possibility of misspecification of the parametric form of the production function. We discuss the benefits of using this test to measure efficiency in more details in Section 5.1.

3. Hypothesis Formulation

While it is probably true that diversification has both value-reducing and value-enhancing effects, it is an empirical question whether diversified firms experience a net benefit (or

[3] The construction of Schoar's samples could account for differences in the findings. Schoar matches firms from the LRD with those existed in the Compustat database in 1987, therefore her sample is more likely to contain larger diversified firms and no firms that have been broken up prior to 1987. These characteristics of the sample could bias the results towards finding diversified firms to be more efficient than focused firms, for Maksimovic and Phillips (2002) find large conglomerates to be more productive than their industry average and bust-ups to be the least productive among all diversified firms.

cost) from diversification. Our study examines the most direct economic consequence of firm diversification—productive efficiency. Specifically, we examine whether 'cross pollination' between several businesses leads to increased or decreased productive performance. We next develop predictions concerning the effect of diversification on firm efficiency.

Our synergy hypothesis is based on the argument that any potential synergy benefits of diversification should directly manifest themselves in a more efficient production. Some of these benefits can arise from economies of scope and elimination of redundant operations. Thus, *ceteris paribus*, diversified firms are predicted to be more efficient than their focused counterparts if managers diversify in pursuit of synergies.

One more testable implication of the synergy hypothesis is that to the extent that related lines of business enjoy more synergies, diversified firms with related segments should be more efficient than firms with unrelated segments. Firms with related segments have a higher probability of realizing complementarities in production and making inter-segment transfers at non-market prices. In other words, operating in multiple business lines allows diversified firms to expand the set of feasible input and output bundles available to them. Analogous to the notion of internal capital markets, creation of 'internal product markets' could be a value-enhancing strategy as it allows firms to blend resources of different segments. Lower input prices should lead to higher output per dollar of inputs. In addition, as noted by Rumelt (1974), skills and resources can be more easily transferred in related markets.

On the other hand, diversification could also add extra costs (e.g., costs of implementing incentive and monitoring programs for managers of internal divisions). Still firms may pursue expansion of the number of business lines due to agency problems. This is because managers are likely to reap more private benefits if they manage a larger or more complex corporation (Shleifer and Vishny (1989), Amihud and Lev (1981)). Moreover, to the extent that agency problems within a firm are substantial, certain beneficial aspects of diversification could be abused. For instance, managers may misuse cross-subsidization available within firms with multiple lines of business by undertaking value-destroying investments. Therefore, the agency-cost hypothesis predicts that efficiency of diversified firms is likely to suffer relative to that of focused firms.

An important caveat, however, is that managers may diversify regardless of whether or not this type of strategy results in efficiency gains. In this case, diversification does not necessarily increase efficiency, but it does not necessarily reduce it either. In fact, if managers want to 'build empires,' it would be in their interest to take measures to improve productivity of their existing firms or to acquire only highly productive firms. Stein (1997) makes a related argument where managers have an incentive to maximize efficiency because the total rents they can divert from firm's operation are positively related to their firms' revenues.

This suggests that while having opposite effects on efficiency, the first two hypotheses—the synergy hypothesis and the agency-cost hypothesis—are not mutually exclusive. That is, it is not sufficient to observe a positive (negative) relation between diversification and efficiency in order to rule out the agency-cost (synergy) hypothesis. If this relationship is strictly positive or negative, this would provide evidence only of the net effect of potential synergy benefits and agency costs associated with diversification. For example, a negative relationship between diversification and firm efficiency implies that any synergy benefits of diversification are being completely eliminated due to more substantial agency costs. In this case, the phenomenon of the diversification discount could be partially explained by differences in efficiency between diversified firms and focused firms.

The next hypothesis is related to potential systematic differences in the level of efficiency among diversified firms based on the method of acquisition of new segments. A firm can diversify through external acquisitions of new businesses or through internal growth. One might argue that if managers' primary objective is to create empires, external acquisitions would be a faster and easier way to achieve their objective relative to internal growth. As Mueller (1995, p.15) notes, mergers, for example, "are the quickest and surest way to grow, and thus may be undertaken by managers even if they do not promise profit and shareholder wealth increases." On the other hand, it is relatively harder to quickly fabricate a larger firm via internal growth. Furthermore, those firms' operations that have grown to be separate segments within their firms are, by nature, likely to be efficient. Hence, one would expect segments of diversified firms that were grown internally to be more efficient than segments that were acquired. In line with this prediction, Graham, Lemmon, and Wolf (2002) show that, unlike firms that expand via acquisitions, firms that increase their reported number of segments through internal growth do not experience a decline in excess value at the time of the segment increase.

4. Data Sources

Our primary source of data for this study is the Longitudinal Research Database (LRD) from the Center for Economic Studies at the U.S. Census Bureau.[4] The LRD is a micro database containing establishment-level data for those establishments whose primary activity is in the manufacturing sector, i.e., Standard Industry Classification (SIC) codes 2000 through 3999. An establishment is a basic economic unit. As defined in the LRD, it is "generally a single physical location where business is conducted or where services or industrial operations are performed" (hereafter, also referred to as plant).

The main sources of data contained in the LRD are the Census of Manufactures (CM) in years ending in '2' and '7' and the Annual Survey of Manufactures (ASM) in other years. The CM covers all manufacturing establishments existed at the time, whereas the ASM includes a subset of only large establishments (with 250 employees or more) and major producers of each product class being surveyed continuously from year to year. According to the LRD documentation, while this subgroup represents only a small number of all establishments, they constitute approximately 70 percent of the total value of shipments of the entire manufacturing sector. The rest of the census universe of establishments is subject to rotation in and out of the ASM through sample re-selection every five years, two years after a census year. The majority of establishments, mainly small single-establishment firms, have data for census years only. It should be noted that while the LRD is based primarily on surveys and censuses, surveyed establishments are required by law to answer questions, and some data items are reported to the IRS. Both of these factors contribute to the reliability of the data.

The fragmented nature of the LRD panel presents a challenge when estimating variables that require information on all establishments of a firm in the same year or on the same establishment across time. To address this issue, we use the LRD in conjunction with the Longitudinal Business Database (LBD) whenever estimation of a variable

[4] For a detailed description of the Longitudinal Research Database, see McGuckin and Pascoe (1988).

requires such information. While limited to a small number of basic data items (such as firm affiliation, industry classification, and payroll), the LBD provides information on establishments' activities outside the manufacturing sector by covering almost all of the non-farm private U.S. economy. The main source of data for the LBD is the Census Bureau's Business Register (or the Standard Statistical Establishment List (SSEL)).[5]

In addition to the Census data, we use the Standard & Poor's COMPUSTAT Industrial Annual Research files (Compustat) to obtain firm-level variables. The other two sources of data for our study are the Center for Research in Security Prices (CRSP) database and the Worldwide M&A Section of the Securities Data Company (SDC) database. The CRSP database is used to obtain the value of firm equity in order to estimate the firm leverage variable. The SDC database provides information on the merger-and-acquisition activity that allows us to infer whether a firm's existing segment was added internally or externally.

The procedure used here to match the Census data to data from other sources is as follows. First, the Compustat data are merged with data in the CRSP and SDC databases, using firms' CUSIP Codes, which are available in all three databases. A CUSIP Code is a six-digit number that uniquely identifies a corporate (as well as, municipal or government) issuer of financial securities. Next we employ the existing 'Compustat-LRD crosswalk' to match the resulting sample with the LRD data. Once we obtain our sample, we use the Census File Number (CFN) as a common identifier to combine data from the LRD and LBD. For each establishment of a multi-unit firm, its CFN's first six digits (out of ten digits) represent the firm code. Thus, the CFN can also be used to aggregate establishment-level values to the firm level.

Among other data sources is the benchmark Input-Output accounts from the Bureau of Economic Analysis. The benchmark Input-Output accounts, published by the Bureau of Economic Analysis at the U.S. Department of Commerce, provide input and output information for each industry and are used to estimate vertical relatedness of firms' business segments.

[5] For a more detailed description of the Longitudinal Business Database, see Jarmin and Miranda (2001).

5. Variable Description

We next discuss variables used in our empirical tests. First, in section 5.1 we describe the methodology for estimating the measure of efficiency. Explanatory and control variables are discussed in Sections 5.2 and 5.3, respectively. For reference, in Table 1 we provide the definitions and sources of all the variables used in the study.

5.1. Efficiency Measure

There are several advantages of looking at the direct impact of diversification on efficiency rather than on the market-based wealth effect. First, the stock price does not always reflect an unbiased estimate of the firm's future dividends or earnings. Further, the price reaction to an announcement to diversify is contaminated by issues other than the direct economic impact of diversification (for example, prior expectations and the chosen method of the transaction). Finally, the evidence from the stock market data on diversification via internal growth might not be traceable due to the inability to pinpoint a specific event date for this process.

There are several commonly used methods of estimating efficiency in the existing literature. These methods are broadly categorized into two groups: the econometric approach and the mathematical programming approach. Both approaches involve estimation of firm efficiency by measuring its deviation from a constructed production frontier, i.e., boundaries of production possibilities. The econometric approach is based on estimating a functional form of the production function and decomposing disturbances from the model into estimates of inefficiency and noise. In contrast, the mathematical programming approach (also referred to as data envelopment analysis (DEA)) is not able to distinguish between inefficiency and noise. Its advantage, however, is that it is based on the nonparametric estimation of the frontier and thus is not vulnerable to its misspecification. DEA efficiency (e.g., cost and revenue efficiency) is generally calculated from the ratio of frontier costs to the firm's actual costs (or the ratio of actual revenues to frontier revenues), where the frontier is established by solving a linear programming problem for each firm in the set.[6]

[6] For more details on different methods of estimating efficiency, refer to Fried, Lovell and Schmidt (1993).

As mentioned earlier, previous studies have primarily utilized the Total Productivity Factor (TPF), which is based on the econometric approach, to measure productive efficiency. The conventional analysis involves estimating a parametric form for the production function, typically a log-linear Cobb-Douglas production function, for all firms in the sample. A drawback of this method is that it requires the specification of a parametric form for the production function. Furthermore, it relies on the underlying assumption that firms' production (or cost) function is correctly specified. Thus, the TPF measure is only as good as its underlying assumption about the production function. However, whether a chosen functional form is a close approximation of the actual production function cannot be directly tested.

To address this deficiency, we employ a non-parametric approach to production analysis—a test based on the Varian's (1984) Weak Axiom of Profit Maximization (WAPM). The WAPM test is similar to other conventional methods of estimating efficiency in that it compares an individual firm's performance to the best observed practice in the sample. However, the main advantage of the WAPM test is that, unlike the econometric approach, it imposes no functional form on the data. In other words, it allows one to directly test the data for efficiency without relying on assumptions about the functional form of the production function. Additionally, the WAPM test does not require a large data set in order to yield robust results.

Next we describe the WAPM test and the associated measure of efficiency that we use in this study. Define the net output vector for observation i, $i = 1, \ldots, n$, as $Y^i = (y_1^i, \ldots, y_k^i)$, where positive components of Y^i are outputs and negative components are inputs. An associated price vector is defined as $P^i = (p_1^i, \ldots, p_k^i)$, where $P^i \geq 0$.[7] This implies that the inner product P^iY^i is profit at observation i. Suppose we observe data on firm behavior, that is, a set of net output vectors Y^i and price vectors P^i. Since we can observe a set of feasible net output vectors (i.e., the production-possibilities set Y), we can test whether, given the price vector, firm i's choice of the net output vector is profit maximizing. A necessary condition for the observed behavior (P^iY^i) to be consistent with profit maximization is $P^iY^i \geq P^iY^j$ for all pairs of observations i and j. In other words, firm i's profit, given the observed choices, must be at least as great as its profit would be from

[7] Price vectors are assumed to be row vectors and output vectors to be column vectors.

any other feasible choice. Varian (1984) refers to this condition as the Weak Axiom of Profit Maximization.[8]

We employ a version of Varian's WAPM test formalized by Hermalin and Wallace (1994). According to their efficiency test, firm *i* is relatively inefficient if another firm *j* generates greater revenues using an input mix that, at firm *i*'s factor prices, would cost less than the input mix firm *i* chose. Formally, firm *i* is inefficient relative to firm *j* if $R_i < R_j$ and $w_i \bullet z_i \geq w_i \bullet z_j$, or if $R_i \leq R_j$ and $w_i \bullet z_i > w_i \bullet z_j$, where R_i denotes the firm *i*'s total revenues, z_i its vector of inputs, and w_i the vector of corresponding factor prices. Since firm *i* could reduce its costs by at least mimicking firm *j*, firm *i*'s observed method of operations is not efficient.

If firm *i* is inefficient relative to firm *j*, firm *j* is also said to dominate firm *i*. As noted by Hermalin and Wallace (1994), the WAPM test is very conservative. Firm *i* fails the test if it is dominated by just a single firm. Therefore, due to errors or outliers, truly efficient firms could be misclassified as inefficient, reducing the power of the regression analysis. Following Hermalin and Wallace (1994), for each year we estimate a more robust measure of relative efficiency—the proportion of comparisons firm *i* fails using the WAPM test. That is,

$$FAILURE\ RATE_i = \frac{\#(D(n))}{\#(\{j \mid R_j \geq R_i\})} \quad ,$$

where # $(D(i))$ denotes the number of firms that dominate firm *i* using the WAPM test and # $(\{j \mid R_j \geq R_i\})$ is the number of firms with revenues greater than that of firm *i*. This ratio equals zero if the firm is fully efficient in the sense that no other firm dominates it, i.e., # (D(*i*)) = 0. In order to facilitate the interpretation of our results, we transform this measure by subtracting *Failure Rate* from one. The new measure, *EFFICIENCY*, equals one (zero) when a firm is fully efficient (inefficient).

We conduct the WAPM test by comparing each establishment's productive performance to those of all other establishments in the same industry in a given year. To

[8] Varian (1984) also formulates the Weak Axiom of Cost Minimization (WACM). However, WACM is a weaker test than WAPM in that a firm might not be exhibiting a profit maximizing behavior, but minimizing its costs of producing an observed level of output.

minimize discrepancies in production inputs and outputs of establishments being compared, we perform the test at the four-digit SIC level, which is the narrowest available definition of an industry. Further, we do not use time-series data for the WAPM test because in that case the implicit assumption of a stable technological set could be violated. Any technological changes that have an effect on a firm's cost structure will potentially bias the results. For example, if a plant at time *t* is dominated by some other plants at a later time, its productive inefficiency can simply be due to its inability to access more advanced technologies available to the other plants at that later time. In this case the cause of inferior productivity is not poor management, but technological limitations at the time. In summary, performing the WAPM test separately within each industry and year allows us to measure efficiency of establishments, while controlling for conditions of their respective industries and time.

In the upcoming analysis, we examine the effect of firm diversification on *segment* efficiency because competition generally occurs at the business-segment level, as opposed to the plant level. To obtain the segment-level measure of efficiency, we take the weighted average of establishments' measures of efficiency. The weights are based on the establishments' shares of the total value of shipments in the segment. A business segment is defined at the two-digit SIC level.

Following the classification of factors of production commonly used in the construction of TFP measures, we group an establishment's inputs into four categories: material inputs, labor inputs, stock of physical capital, and electric energy (see, for example, Lichtenberg and Siegel (1987) and Lichtenberg (1992a)).[9]

Material inputs for an establishment are all raw materials, parts, supplies, and fuel put into production or consumed (e.g., used in repair and maintenance) by the establishment during the year. Material inputs include materials purchased, withdrawn from inventories and transferred from other establishments of the same firm. Costs of material inputs are the corresponding amounts paid, including delivery and other charges incurred in acquiring these materials, plus the cost of contracted work (i.e., work done by others on materials supplied by the establishment) minus the cost of resales (i.e., products

[9] All inputs and outputs are expressed in current dollars. Since comparison of plant efficiency is made across plants within the same year, it is sufficient to have variables expressed in nominal values, as opposed to real values.

bought and resold without being used in production). Unfortunately, material cost data are not available separately by product and thus are not sufficient to determine prices for different material inputs used by an establishment in its production. Therefore, we assume that material inputs have the same prices across establishments in the same industry in a given year.

The LRD provides comprehensive information on labor, including data on both production and non-production employees. We treat these two types of labor as separate inputs. The quantity of production labor input is the total production-worker man-hours worked or paid for during the year. The quantity of non-production labor is the number of non-production employees employed by an establishment during the pay period. The cost of production labor is estimated by dividing the establishment's total wages and salaries paid to production workers by the number of production-worker man-hours. Similarly, the cost of non-production labor is estimated by dividing the establishment's total wages and salaries paid to non-production personnel by the number of non-production employees. The total wages and salaries include any payments to legally required or voluntary fringe benefit programs.[10]

Estimates of capital stock for each establishment are constructed separately for building assets and machinery assets. To address any potential discrepancies between book and market values of capital sock, we construct a time series of capital stock estimates using the perpetual inventory method, represented by the following equation:

$$K^i{}_t = K^i{}_{t-1}(1-\delta^i{}_t) + I^i{}_t, \qquad i \in (\mathrm{B}, \mathrm{M})$$

where K_t is the capital stock, δ_t is the rate of depreciation of the capital stock, I_t is gross investment, and B and M denote buildings and machinery, respectively. Rates of depreciation used in this process are industry-level average economic depreciation rates. Gross investment includes expenditures made on new as well as used buildings and equipment. If an establishment reports having rental payments for buildings or machinery in a certain year, we capitalize these payments and add them to that year's capital stock. Rental data are capitalized by dividing rental values by asset-specific annual rental rates. Both depreciation and rental rates by asset type are obtained from the Office of

[10] These supplementary payments are not reported separately for production and non-production labor. We allocate them pro-rata based on the number of workers in each category.

Productivity and Technology at the Bureau of Labor Statistics (BLS).[11] The initial values of building and machinery for each establishment are taken to be their earliest book values available to us in the LRD (that is, since 1972).

In applying the perpetual inventory method, annual estimates of capital stock are generated based on prior-year values of capital stock. Therefore, we have to address an issue of missing values for variables that are used in estimation of current-year capital stock. Missing values in our time series are primarily due to an establishment not being surveyed in the LRD in one or more non-census years. We impute any missing values for each establishment's investment and rental variables by applying linear interpolation based on the nearest adjoining non-missing observations for the same establishment. We form the cost of capital stock as the ratio of total capital expenditures to total assets.

The final input is electricity. The quantity of electricity is defined as kilowatt hours of electricity purchased from other firms, transferred from other establishments of the same firm or generated during the year. We exclude any electric energy sold or transferred to other plants of the same firm. The cost of electricity is the amount paid or payable for electric energy.

Finally, output in dollars for an establishment is defined as the establishment's reported total value of shipments during the year, adjusted for annual changes in inventories of finished goods and work-in-progress. The value of shipments includes the total value of products shipped for sale or transferred to other plants of the same firm, receipts for contract work performed for others, the selling value of products resold without further processing and miscellaneous receipts.

5.2. Explanatory Variables

Diversification measure.

The LRD provides information on industrial activity of establishments. However, using the LRD alone to measure business diversification may lead to the underestimation of the true extent of establishments' operations across different industries for two reasons. First, non-manufacturing establishments are outside the scope of the LRD. Second, even some

[11] Type-of-asset codes used here for buildings and machinery are 28, *Industrial Buildings*, and 13, *General Industrial, Including Materials Handling, Equipment*, respectively. Estimates of economic rates of depreciation are at the two-digit SIC level.

manufacturing establishments are excluded from the LRD in non-census years. This is due to the sampling design of the ASM, which is described in Section 4. To overcome the limited scope of the LRD, we estimate all diversification-related variables for establishments in our sample using industrial activity data from the LBD.[12]

The main advantage of using the establishment-level Census data in measuring firm diversification is that it avoids the self-reporting nature of segment classification that afflicts COMPUSTAT Segment files. Villalonga (2004) observes, for example, that the extent of diversification obtained from the COMPUSTAT Segment files is substantially underestimated relative to that obtained from the Census data when same exact firms are used as the sample.

Diversification is defined at the two-digit SIC level.[13] In estimating the diversification variable, *DIV*, two alternative proxies are constructed. The first measure is a version of the sales-based Herfindahl Index (*HERF*) used in Berger and Ofek (1995). It is designed to capture the degree of a firm's concentration across its business segments. The Herfindahl Index used here is defined as one minus the sum of the squares of each segment's employment, reported on March 12, as a proportion of the firm's total employment. Thus, for firm i in year t,

$$HERF_{it} = 1 - \sum_{j=1}^{N_{it}} \left(E_{jit} \Big/ \sum_{j=1}^{N_{it}} E_{jit} \right)^2 \quad ,$$

where E_{jit} is number of employees in segment j of firm i in year t and N_{it} is the number of segments of firm i in year t. *HERF* equals zero when a firm operates only in a single segment and is between zero and one when a firm has operations in multiple segments.

The second diversification measure is the natural logarithm of the number of segments a firm reports in the current year, log(*NUMSEG*).

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[12] The LBD data for the year 2000 were not yet available at the time of the study. For that year, we supplement industry information from the LRD with data from the COMPUSTAT Segment files. To identify industry participation of establishments, we use their assigned SIC codes, which are available across all our sample years in all of the employed databases.

[13] Our sample period covers two industry-classification regimes: the Standard Industry Classification (SIC) system and The North American Industry Classification System (NAICS). The latter was introduced in the year 1997 in place of the existing SIC system. While the SIC system classifies firms into industries on the basis of the similarities of their products, the NAICS classifies firms into industries on the basis of the similarities of their production processes.

Relatedness measure.

While measuring a degree of diversification, the number of firm segments and the Herfindahl Index do not reflect whether segments of the same firm are in any way operationally related to each other, which could be an indicator of the possibility for synergy effects. Hence, we form two additional diversification variables: *H. RELAT* and *V. RELAT*. The variables are respectively defined as the number of other segments within the same firm to which the segment in question is horizontally (vertically) related at the two-digit SIC code, scaled by the total number of the firm's segments at the corresponding level minus one.

Horizontally-related segments are identified by a common one-digit SIC code. On the other hand, segments within a firm are classified as vertically integrated if their corresponding industries receive (or supply) at least five percent of their inputs (outputs) from each other. Input and output information for each industry is obtained form the benchmark input-output (I-O) accounts published by the Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce[14]. We employ the 'Use Table' of the I-O accounts that contains information on inter-industry commodity flows. Specifically, the table shows estimates of the dollar value, in producers' prices, of each commodity used by each of about 500 industries.[15,16] The once-every-five-year benchmark I-O accounts are based primarily on data from the economic census conducted every five years by the Bureau of the Census. To the extent that changes in inter-industry commodity flows documented in census years occur gradually, the I-O data in the benchmark I-O accounts are applicable for immediate years surrounding the benchmark years. We use the 1972, 1977, 1982, 1987, 1992, and 1997 I-O data to measure the degree of vertical relatedness of segments during the 1972-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994 and 1995-1999 periods, respectively.

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[14] Among studies that have used the I-O accounts to supplement data from the LRD are Schoar (2002), Maksimovic and Phillips (2001), and McGuckin, Nguyen, and Andrews (1991).

[15] See Lawson, Bersani, Fahim-Nader, and Guo (2002) for details.

[16] The Input-Output (I-O) accounts use six-digit I-O codes to classify industries and commodities. We match I-O codes with the corresponding four-digit SIC codes (and six-digit NAICS codes for the benchmark year 1997) using the concordance tables published by the Bureau of Economic Analysis. Since both the I-O classification system and SIC system have undergone periodical changes to their industry classifications, we use the 1972, 1977, 1982, 1987, 1992 and 1997 concordance tables to convert I-O codes into SIC codes separately in each corresponding benchmark year.

External versus internal growth.

Under Generally Accepted Accounting Principles, firms are required to report any merger and acquisition activities in footnotes of their filings for that year. We use an indication of a major merger or acquisition available in the COMPUSTAT Industrial Annual Research files (footnote code AB) and the Worldwide M&A Section of the SDC in order to classify a segment as being added through external acquisition. If we find no information regarding any merger or acquisition in the year a new segment is first reported, we accept this as evidence for the prior existence of this business line. We classify that segment as being added through internal growth. In doing this, we only consider segment additions that occur up to three years prior to measuring that segment's efficiency. We choose a three-year window to allow for a potential time lag in efficiencies to take full effect. Thus, the addition-type dummy variable, *ADDTYPE*, is set equal to one if the firm's segment is added internally within the last three years and equal to zero if the segment is added through an acquisition.

5.3. Control Variables

To determine the true effect of corporate diversification on efficiency, we control for factors, other than diversification, that may influence firm and/or establishment efficiency. These control variables are firm size, segment size, leverage, and plant age.

The first two variables control for size-related effects, such as economies of scale, on efficiency. Lichtenberg (1992b), for example, provides evidence that large firms tend to be more productive than small firms. Demsetz (1973) and Peltzman (1977) also document that the largest firms in an industry tend to be most efficient in that industry. Their premise is that some firms have above-average values of unobservable characteristics, such as managerial talent, that lead to cost advantages. These firms tend to expand to capitalize on those advantages. Firm size, *FIRM SIZE*, and segment size, *SEGMENT SIZE*, are proxied by the natural logarithm of the firm's total assets and the number of establishments a firm operates within the segment, respectively.

We control for a positive effect of debt on efficiency with the leverage variable, *LEVERAGE*. A firm that is more leveraged is presumed to be under more external, as well as internal, monitoring since the presence of debt in the capital structure of a firm introduces an increased probability of bankruptcy. Thus, a higher debt level should lead to a stronger incentive for managers to ensure that their firms are operated efficiently. Firm leverage is measured as the book value of total debt (current liabilities plus long-term debt) divided by the total value of financial claims (the sum of the book value of total debt, the book value of preferred stock, and the market value of equity). The ratio is averaged over the current and previous years.

Finally, plant tenure may reflect technological variation among plants and thus account for differences in productivity. According to the so-called 'vintage effect,' younger plants are characterized by a better productive technology and capital and therefore should be more productive. However, there is also an opposing effect of plant age on productivity—the 'survival effect.' The logic is that older plants achieve more experience, learning, certain economies of scale, and other factors that are not available to their younger peers. In fact, the mere fact that a plant has survived for an extended period of time might be due to its efficiency. Jensen, McGuckin, and Stiroh (2001) provide evidence that plant age is a good predictor of plants relative ranking in the productivity distribution, with the 'vintage effect' and 'survival effect' both influencing, with opposite signs, productivity. The plant age variable, *PLANT AGE*, is defined as the weighted average of numbers of years of operation by a firm's plants in the same segment, with the weights based on each plant's total value of shipments. The initial year of operation is taken to be the first year the plant appears in either the LBD or LRD[17]. For those plants that existed in the LRD in the first year of its coverage, which is 1972, their initial year of operation is set to that year. The problem of potential underestimation of age of plants with left-censored data diminishes in each subsequent year as those plants disappear and new plants emerge. Having our sample period begin several years after 1972 (i.e., in 1976) and cover an extensive time span mitigate this problem to some extent.

[17] The LBD provides more comprehensive longitudinal linkages and has a superior longitudinal identifier, lbdnum, compared to the LRD. However, the LBD has data back to only 1976. Therefore, to maximize the time period over which we track plants' tenure we also utilize data from the LRD for the 1972-1975 period.

6. Empirical Analysis

6.1. Sample Description

Our sample spans the time period between 1976 and 2000 and initially included all establishments covered in the LRD. The main attrition of the sample occurred after merging the LRD with Compustat database since the latter contains data for public firms only. As a result, our sample excludes establishments that are covered by the LRD, but are owned by private companies.

In addition, we exclude from the sample establishments whose data were imputed as opposed to being reported. According to the LRD documentation, these so-called administrative records (AR) are generally single-establishment firms with a limited number of employees.[18] We also eliminate establishments that were inactive, establishments with missing or unusual data for any of our variables, and establishments with a value of zero for any production inputs or outputs. As in Maksimovic and Phillips (2001), very small establishments with a total value of shipments of less than 10 million 'real' dollars (in 1987 dollars) were excluded from the analysis.

Since misestimation of the degree of firm diversification may lead to spurious conclusions, we ensure maximum accuracy in measuring the diversification variables by excluding firms from our sample if at least one of their establishments has a missing or ambiguous (e.g., SIC code of zero) SIC code.

Further, in calculating plant efficiency, we require a minimum of two separate firms conducting business in each of the four-digit SIC industries during the same year. This condition precludes a situation where an industry is comprised entirely of establishments owned by the same firm. Since the WAPM test produces efficiency measures that are based on relative performance, establishments under common ownership would be assigned opposite efficiency scores just by being the only members in the same industry.

The sample-selection process described above yields a final sample of 41,054 individual establishments. These establishments represent 3,737 firms, out of which about one-third (1,406) are focused firms. Aggregating data to the segment level

[18] Prior to 1977, administrative records were defined as establishments with ten employees or fewer. Today the cut-off differs by industry.

produces a sample of 61,655 segment-years (where business segments include segments of diversified firms as well as single-segment firms).

We present descriptive statistics for our final sample in Table 2. Panel A, which reports segment-level statistics, shows that the average number of plants and employment per business segment are relatively stable throughout the sample period. An average manufacturing division of a sample firm has about 8 plants with a total of 1,900 workers. However, the associated standard deviation of about 14 plants implies a wide dispersion in the size of segments. Firm-level descriptive statistics in Panel B of Table 2 show that firms in the sample on average operate 5 business segments. The relatively large number of segments per firm accords with Villalonga's (2004) observation that the extent of diversification using the Census data is substantially higher than that found using segment financial reporting in Compustat. An average firm in our sample has approximately 16 plants, 3,848 employees and almost 1.4 billion in total assets. While these statistics indicate that our sample contains predominantly large firms, their standard deviations again point to a significant dispersion in the size of the sample firms. Looking at the degree of corporate diversification over time, we observe a steady trend among firms towards reducing the number of their business segments, which in turn leads to a corresponding decrease in the average number of establishments and employment per firm. However, while becoming more focused over time, firms also become considerably larger as measured by total assets at the firm level and total value of shipments at the plant level. An average firm in the last time period (1996-2000) of our sample is about 4.5 times larger in term of total assets than an average firm 20 years earlier. Interestingly, firms were able to grow without a corresponding upward trend in the size of their work force. In fact, the average firm-level employment went down by about 30 percent over the same time period, which is likely due to technological advances.

Table 3 provides a further look at the degree of diversification among firms that operate in the manufacturing sector. The distribution of firm-years across number of segments reveals that the majority of firms have no more than four two-digit SIC segments, with the modal value of two segments. To examine dynamic changes in the level of corporate diversification, in Figure 1 we present the frequency distribution of proportions of firm-years by number of segments in each five-year time period.[19] Again, the observed general trend is that firms became less diversified over the sample period. The most significant changes are observed in the tails of the distribution: The proportion of firms with more than 15 segments fell sharply, while that of single-segment firms increased drastically from 8 to 21 percent over the 1976-2000 period.

Table 4 provides descriptive statistics for the sample by industry, where an industry is defined at the two-digit SIC level. All industries within the manufacturing sector, i.e., two-digit SIC codes 20 through 39, are well represented in our sample. The smallest number of segment-years, comprising only 0.3 percent of the entire sample, comes from the tobacco-manufacturing industry (SIC code 21). This unusually small number of tobacco manufacturers, when compared to the number of observations representing other industries in the sample, is due to a relatively small size of the industry itself. On the other hand, the average number of plants operated by the same firm in a given industry varies significantly across the industries. With an overall average number of about 8 plants per segment, this statistic for specific industries ranges from 4 plants (for SIC code 39: Miscellaneous manufacturing industries) to 18 plants (for SIC code 26: Paper and allied products). Finally, the proportion of pure-play firms in most industries is low, indicating that the overwhelming majority of firms have operations outside a given industry. In particular, the lowest proportion of focused firms, less than two percent, is observed in the petroleum-and-coal-products industry (SIC code 29), and the largest share of focused firms at 16.5 percent is found in the electrical-and-other-electronic-equipment industry (SIC code 36).

Statistical properties of the efficiency measure for segments in our sample are reported in Table 5. Panel A shows that the average segment efficiency is consistently high and relatively stable at about 0.88 throughout the entire sample period. (Recall that *EFFICIENCY*=1 indicates a fully efficient segment.) The high level of efficiency among business segments may be the result of generally competitive product markets within the U.S. manufacturing sector, where inefficient businesses would not survive for a long time. The observed high efficiency may also be driven by some sample-specific

[19] We are not able to report the proportion of firm-years with 15, 16, 17, etc. segments separately because the number of firms in those categories does not meet the confidentiality criteria of the Census Bureau.

characteristics found among our observations, such as large firm size and being publicly traded.

Next we perform a longitudinal analysis of the stability of the segments' efficiency and present the results in Panel B of Table 5. At the beginning and end of the 1977-1982, 1982-1987, 1987-1992, and 1992-1997 periods as well as the overall period of 1977-1997 all sample segments are ranked based on their efficiency within their two-digit SIC codes and grouped into quintiles, where group 1 contains the most efficient segments and group 5 contains the least efficient segments.[20] A value in each table presented in Panel B shows the number of firm segments, as well as the corresponding percentage of those segments, that transitioned from the column group to the row group over a given period. We observe that the segments are most likely to maintain their level of efficiency as opposed to changing it over the five-year periods, as indicated by the relative proportion of the segments in each column group on the diagonal in all the tables. This effect is especially pronounced for group 1 (the most efficient segments) and group 5 (the least efficient segments). Generally, the most stable group in terms of efficiency is group 5. Approximately 40 percent of the least efficient segments compared to their industry's peers remain so over the next five years. As expected, segment efficiency among all groups in the overall 1977-1997 period is less stable than it is over shorter periods of time.

Univariate descriptive statistics for the full sample are presented in Table 6. We also report corresponding statistics for a subsample of focused firms (i.e., with one segment) and that of diversified firms (i.e., with more than one segment) and t-tests for differences in means between the two subsamples. Plant-level variables, including production variables used to estimate efficiency, are presented in Panel A of Table 6. The average plant age for firms in both subsamples appears to be the same at about 13 years. Plants of diversified firms tend to have a larger scale of production than plants operated by focused firms. This size difference, as measured by both the total value of shipments and total employment, is statistically significant at the 1-percent level. In line with their larger size, plants of diversified firms utilize statistically significantly larger quantities of

[20] We use census years to define the boundaries for the time periods in order to maximize the number of common observations in the beginning and end of each period.

production inputs and generate higher levels of output. As for the input prices, plants of diversified firms have lower costs of both production and non-production labor. This is consistent with the argument in Stulz (1996) that firms that aim to reduce the probability of financial distress through risk management—via for example diversification—should be able to enjoy lower wages. The premise is that stakeholders, such as employees, are poorly diversified due to their typically large stake of the company in their personal portfolios, and therefore, they are willing to take lower pay in return for the relative job security in a company that hedges its risks. We find no statistically significant differences in the mean prices of capital stock and electricity for the two types of plants.[21]

The size difference between stand-alone and diversified firms is even more pronounced at the segment level, as indicated by statistics presented in Panel B of Table 6. As indicated by the relative magnitudes of size-related variables (total value of shipments, total assets and total employment), segments of diversified firms are substantially larger than those of focused firms. This observation is driven primarily by the fact that segments of diversified firms have about three times more plants per segment than their focused counterparts. Panel B also reveals that segments of focused firms appear to be only slightly more efficient than segments of diversified firms, albeit at a statistically significant level. Next we test whether this efficiency superiority of focused firms holds in a multivariate setting, after controlling for factors that may affect productive efficiency.

6.2. Empirical Tests of Hypotheses

In order to examine the systematic differences in efficiency between diversified and focused firms, we estimate several regression models. All regressions are estimated at the two-digit SIC segment level, using unbalanced panel data.

The effect of diversification on efficiency.

To test the effect of corporate diversification on segment efficiency implied by the synergy and the agency-cost hypotheses, we specify a Tobit model, where the dependent

[21] The cost of the material input is assumed to be the same across establishments in the same industry in a given year because of the lack of material-cost data separately by product.

variable, *EFFICIENCY*, is censored at 0 and 1. The dependent variable is regressed on a set of explanatory and control variables discussed in Section 5.2 and 5.3, respectively. Thus, the test specification is as follows:

$$EFFICIENCY_{jit} = \alpha_0 + \alpha_1\, DIV_{it} + \alpha_2\, H.\ RELAT_{jit} + \alpha_3\, V.\ RELAT_{jit} + \alpha_4\, DIV_{it}{\times}H.\ RELAT_{jit} + \alpha_5\, DIV_{it}{\times}V.\ RELAT_{jit} + \alpha_6\, SEGMENT\ SIZE_{jit} + \alpha_7\, FIRM\ SIZE_{it} + \alpha_8\, LEVERAGE_{it} + \alpha_9\, PLANT\ AGE_{jit} + \varepsilon_{jit}, \quad (1)$$

where

$EFFICIENCY_{jit}$ = Measure of efficiency of segment *j* of firm *i* in year *t*, as defined in Section 5.1.

DIV_{it} = Measure of diversification of firm *i* in year *t*, as defined in Section 5.2.

$H.\ RELAT_{jit}$ = 1 if segment *j* of firm *i* is horizontally related to another segment of the same firm in year *t*,
= 0 otherwise.

$V.\ RELAT_{jit}$ = 1 if segment *j* of firm *i* is vertically related to another segment of the same firm in year *t*,
= 0 otherwise.

$SEGMENT\ SIZE_{jit}$ = The natural logarithm of the number of establishments firm *i* operates within segment *j* in year *t*.

$FIRM\ SIZE_{it}$ = The natural logarithm of firm *i*'s total assets in year *t*.

$LEVERAGE_{it}$ = Firm *i*'s book value of total debt divided by the sum of the book value of total debt, the book value of preferred stock, and the market value of equity. The ratio is averaged over years *t* and *t*-1.

$PLANT\ AGE_{jit}$ = The weighted average of numbers of years of operation by firm *i*'s establishments in segment *j*, with the weights based on each establishment's total value of shipments.

Table 7 presents coefficient estimates from different specifications of the above model.[22] We estimate two-way fixed effects specifications of the model to account for

[22] To assess the robustness of our Tobit estimators, we check them against corresponding estimates obtained from OLS regressions. Significance tests for the OLS coefficient estimates are based on the standard errors that are obtained from White's (1980) heteroskedasticity-consistent estimates of the

any omitted relevant industry-specific and time-specific factors.[23] Generally, our results hold regardless of regression specification. Consequently, we concentrate on discussing results obtained from the Tobit regressions with industry and year fixed effects.

First, we examine model specifications in columns (1) through (4) of Table 7. Consistent with the predictions of the synergy hypothesis, the impact of firm diversification (evaluated when the relatedness variables are set equal to zero, that is, a segment is neither horizontally nor vertically related to any other segment of the same firm) on efficiency is positive and highly statistically significant across all specifications. While this finding holds using the two alternative proxies for diversification, *HERF* and log(*NUMSEG*), the effect is about twice as strong when the degree of diversification is measured using the Herfindahl index. Our finding of a positive impact of firm diversification on efficiency mirrors the 'productivity premium' associated with plants in diversified firms found in Schoar (2002). Hence, using the two alternative methodologies to measure productive efficiency, i.e., the WAPM test and the TFP, both studies yield the same result when analyzing data from the same source. Furthermore, the finding in this study is consistent with the 'diversification premium' obtained by Villalonga (2004) using the Census data.

The relatedness variables capture the differential effect of operating horizontally and vertically-related segments versus unrelated segments on efficiency. In addition, we introduce the corresponding interaction terms to allow the impact of diversification to vary based on the segment's horizontal and vertical relatedness. While horizontal relatedness is neither economically nor statistically significant, vertical integration contributes positively to segment efficiency. Since *V.RELAT DUMMY* is a dummy variable, its coefficient captures a positive mean difference in efficiency between vertically-related segments and unrelated segments (evaluated at the sample mean of the diversification variables, which are mean-centered). The herein-documented positive impact of vertical integration within a firm on its efficiency supports the finding in Fan and Goyal (2006) that vertical mergers create significant positive wealth effects. Further,

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variance-covariance matrix. In addition, we check whether any outliers have a significant impact on our results by windsorizing the efficiency measure at the 1st and 99th percentiles of the distribution. After performing both robustness checks, the results remain qualitatively the same as those presented in Table 6.

[23] The Hausman test suggests the use of the fixed effects model over an alternative random effects model, as the null hypothesis of no correlations between the random effects and the regressors is rejected.

statistically significant regression coefficients on most of the interaction terms indicate that there are differences for the effect of diversification on efficiency between the group of related segments and that of unrelated segments. The effect of diversification on efficiency is more positive if the diversification is associated with vertical integration of businesses as opposed to when internal businesses are unrelated. However, the positive effect of diversification on efficiency weakens with horizontal integration. This is expected as, for example, a diversified firm with no horizontal integration (i.e., no segments with the same one-digit SIC code) is, in effect, more diversified than a counterpart with the same level of nominal diversification but with horizontally-related segments. Therefore, any efficiency benefits that come from being diversified diminish as business segments become more similar.

All the control variables—size, leverage and plant age—have a negative effect on efficiency and are highly significant at the 1-percent level. It appears that impediments associated with operating a large business offset any benefits from economies of scale. Further, consistently negative coefficients on the *PLANT AGE* variable across all the regression specifications lead us to reject the 'survival effect' in favor of the 'vintage effect.' According to the latter argument, older plants are inherently more likely to employ substandard technologies and assets and, thus, be less efficient compared to their younger counterparts.

In explaining segment efficiency, we have not considered the effect of the quality of managerial decision making on business segments. It is possible that efficiency is simply the result of superior management regardless of what type of firm those managers run. To examine whether firm diversification has an effect on segment efficiency beyond that of overall firm management quality, we include the *FIRM EFFICIENCY* variable in columns (5) and (6) (one for each measure of firm diversification) of Table 7.[24] Firm efficiency proxies for the overall quality of firm management as better managers tend to achieve and maintain higher firm efficiency. The two regressions contain only firms with operations limited to the manufacturing sector. Efficiency at the firm level could be estimated only for manufacturing firms because our production data are limited to that

[24] *FIRM EFFICIENCY* is estimated using the weighted average of the establishments' measures of efficiency. The weights are based on the establishments' shares of the total value of shipments in the firm.

sector. As a result of this, the sample dropped to 9,907 observations. Further, the regressions are restricted to firms with firm efficiency measures available for the past two years. The resulting sample includes 7,280 segment-years.

Both the *HERF* variable and the log(*NUMSEG*) variable remain positive and significant at the 1-percent level. As expected, the sign on the *FIRM EFFICIENCY* variable is also positive and statistically significant, suggesting that segments that belong to overall well-run firms also tend to be more efficient. However, we don't find evidence that past firm productive performance, measured by two lags of *FIRM EFFICIENCY*, has a significant impact on the current segment efficiency. Interestingly, the *V. RELAT* variable reversed sign and became significantly negative in the new regression specifications. One explanation for this could be sample selection, where the model is estimated for the segments of firms with manufacturing operations only. It appears that there is some negative impact of having vertical integration in manufacturing on efficiency. For example, in a 15-year study of mergers around the world, Gugler et al. (2003) find that both vertical and horizontal mergers in the manufacturing sector are less profitable than those in the service sector. Furthermore, they document that, unlike a horizontal merger, a vertical merger in the manufacturing sector is significantly less profitable than an average merger in the same sector.

In Appendix, we provide a discussion of several robustness checks that we perform in order to account for services not incorporated in plants' costs. Such services include those that plants may purchase from other firms or consolidate at central offices located offsite.

The effect of method of segment addition on efficiency

We explore whether different methods through which new segments are added have different consequences for these segments' future operating performance. Do segments that emerge naturally through internal growth have superior productive performance relative to segments that are added through external acquisitions? To examine this question, we add a new variable, *ADDTYPE*, to equation (1) in order to explain the observed level of segment efficiency in the short run after the segment was added to the business mix. *ADDTYPE* is a dummy variable that is set equal to one if the segment is added through a merger or acquisition and zero if it is internally grown. Thus, we estimate the following Tobit model:

$$EFFICIENCY_{jit} = \beta_0 + \beta_1\, DIV_{it} + \beta_2\, ADDTYPE_{ji[t\text{-}3,\,t]} + \beta_3\, H.\ RELAT_{jit} + \beta_4\, V.\ RELAT_{jit} + \beta_5\, SEGMENT\ SIZE_{jit} + \beta_6\, FIRM\ SIZE_{it} + \beta_7\, LEVERAGE_{it} + \beta_8\, PLANT\ AGE_{jit} + \varepsilon_{jit}, \quad (2)$$

where

$ADDTYPE_{jit\text{-}3,t}$ = 1 if segment j of firm i is added through external growth at time between t-3 and t,
= 0 if segment j of firm i is added through internal growth at time between t-3 and t.

The other variables are the same as those described in equation (1).

The above specification is estimated for a subsample of diversified firms that reported a new two-digit SIC segment in the past three years. In compiling a sample of newly-added segments, we excluded those segments for which the initial year of firm operation could not be determined. Knowing the first year of a firm's operation prevents us from considering the year when segments are first reported and erroneously characterizing those segments as newly added to an existing firm. The deleted observations include—but are not limited to—segments with the earliest reported year of 1976, which is the first observation year in the LRD. Next, for each identified segment addition, we use only observations within the three-year period following its addition.[25] We were able to identify 2,722 diversified firms that added one or more segments within a three-year period and for which we could determine the method of their segment addition. This sample of firms represents 11,823 segment-years over the 1977-2000 period.

Tobit regression results are presented in Table 8.[26] The variable of interest here is *ADDTYPE*, which has a positive sign and is statistically significant at the 1-percent level in most regression specifications. This implies that segments that are acquired tend to perform, on average, better than internally-grown segments. This finding does not support the hypothesis that managers pursue acquisitions solely for the sake of managing

[25] Excluding the year of segment addition from the three-year period does not change the regression results.
[26] We obtain similar results using OLS regressions (not reported).

a larger and more complex company. In most cases, the signs of other regression coefficients remain the same as those in the full sample. The only exception is the *HERF* variable, which becomes significantly negative when the firm efficiency is included into the model specification for a subsample of diversified firms.

We further investigate whether the degree of diversification and other segment and firm characteristics have a differential impact on a segment's efficiency based on the method of that segment's addition. Table 9 presents the results from estimating a modified regression (2), where the *ADDTYPE* variable is interacted with all other variables in the regression. The columns labeled 'Internal' contain estimation results for regressions with the *ADDTYPE* variable set equal to zero if the segment is grown internally and one if the segment is added externally. Thus, the coefficients in the 'Internal' columns show the effects of specified segment and firm characteristics on efficiency of internally-added segments only. The columns labels 'External' have the *ADDTYPE* variable re-defined such that it is set equal to zero if the segment is added externally. The results in the columns labeled 'Difference' indicate whether any effects on segment efficiency are statistically different for the two types of segment additions.

The results are qualitatively similar for both sets of regressions with the two alternative measures of firm diversification. Both *HERF* and log(*NUMSEG*) have negative regression coefficients in the 'internal' specification and positive coefficients in the 'external' specification. It appears that the degree of firm diversification is negatively related to efficiency of internally-added segments, but positively-related to efficiency of externally-added segments. Furthermore, the impact of firm diversification is statistically significantly different for the two types of segments. This finding may indicate that newly-added divisions have more opportunities to realize immediate synergies and other benefits from a more diverse firm during the first three years post acquisition than internally-grown divisions that are not truly new to the firm, but simply became large enough to be reported for the first time as new business segments. The regression results with respect to vertical integration further support this argument: The more vertically integrated a newly-acquired segment is with the rest of its firm the more efficient it tends to be in the short run after the acquisition. On the other hand, a higher degree of horizontal integration, which implies less diversification, does not seem to contribute to better efficiency of acquired segments. The rest of the variables do not have a significantly different impact on efficiency of internally-grown and acquired segments, with the exception of *PLANT AGE*, which is significantly different for the two types of segments at just 10-percent significance level.

Thus taken together, the findings suggest that newly-acquired segments tend to exhibit higher efficiency than just-added internally-grown segments. Furthermore, acquired segments fare better, at least in the short run, if they join a firm with a higher degree of diversification.

Firm efficiency and the likelihood of segment acquisition

In this section, we examine whether firms' choice to grow internally or add a segment through an acquisition is influenced by firms' overall efficiency. To explore this question, we estimate the following Probit model:

$$ADDTYPE_{jit} = \lambda_0 + \lambda_1\, FIRM\ EFFICIENCY_{it} + \lambda_2\, FIRM\ EFFICIENCY_{it\text{-}1} + \lambda_3\, FIRM\ EFFICIENCY_{it\text{-}2} + \lambda_4\, H.\ RELAT_{jit} + \lambda_5\, V.\ RELAT_{jit} + \lambda_6\, FIRM\ SIZE_{it} + \lambda_7\, LEVERAGE_{it} + \varepsilon_{jit}\,, \tag{3}$$

where

$ADDTYPE_{jit}$	= 1 if segment *j* of firm *i* is added through external growth in year *t*, = 0 if segment *j* of firm *i* is added through internal growth in year *t*.
$FIRM\ EFFICIENCY_{it}$	= Measure of efficiency of firm *i* in year *t*, as defined in Section 5.1.

The other variables are the same as those described in equation (1).

We include two lags of *FIRM EFFICIENCY* in the estimation to capture the effect of firm efficiency at a time of the decision to make an acquisition, as opposed to when a segment is already added to the firm. Table 10 shows that *ex ante* firm efficiency is positively related, at the 5-percent significance level, to the probability of a segment being acquired, perhaps reflecting efficient firms' superior abilities in running acquired businesses. This result parallels the finding in Maksimovic and Phillips (2001) with respect to buyers of whole firms. They report that "firms are more likely to be buyers when they are efficient." From examining the *FIRM SIZE* variable, it is apparent that larger firms are more likely to add a new business segment through an acquisition than to grow it internally. While this may be the result of more financial resources being available to larger firms for merger and acquisition activities, we find no significant effect of firm leverage on the likelihood of segment acquisition.

Efficiency and the likelihood of a divestiture

Next we examine the relationship between segments' performance and the likelihood of their subsequent divestitures. A segment is classified here as divested if *all* establishments within that segment's two-digit SIC code are sold or leased in the same year, for this indicates a move towards an increase in focus by the parent. This procedure ensures that a partial sell-off, where only a few of a segment's assets are sold and the whole segment remains an operating entity, is excluded from the analysis. In addition, a segment shutdown as part of a complete exit by, or an acquisition of, the entire firm is not considered to be a means of refocusing and therefore is excluded from being categorized as a divestiture. To identify changes in establishments' operational status, we use two complimentary screening procedures. The LRD contains codes that indicate changes in the operational status of establishments (e.g., closed, sold, leased, dismantled, etc.), however, it is not consistent in reporting all such operational changes in every year of the sample period. Therefore, we supplement this information by tracking establishments over time in the LBD and identifying any *explicit* changes in the establishments' status or ownership.[27]

If firms tend to eliminate poorly-performing assets, then the propensity to divest a segment should decrease in the level of its prior performance. Thus, a negative sign on the efficiency variable would be consistent with implications of the synergy hypothesis and would indicate that the management does not hold on to underperforming assets. On the other hand, a positive relationship between segments' performance and the likelihood

[27] Relying on data from the LRD (as opposed to the LBD) to observe operational changes has two limitations, which stem from the fact that in non-census years the database provides coverage of only a subset of the entire U.S. manufacturing sector. First, the absence of one or more establishments of the same firm from the LRD in a particular year may result in some segments being erroneously classified as divested. For example, a segment with two plants, one of which was sold, will be identified as divested if only the sold plant is covered by the database. The second issue is the inability to observe changes in industry participation across years for those firms that have broken longitudinal links in the LRD.

of their sale does not necessarily support the agency-cost hypothesis. While it could indicate that poorly-performing divisions are retained, it also implies that well-performing businesses are sold. However, what it may suggest is that the market for corporate assets is more favorable to efficient assets.

We also control for factors that are not directly related to segment efficiency, but that have been shown in the literature to influence firms' decisions to sell assets; specifically, financial need, asymmetric information, size and, industry growth. Firms may choose to divest their segments to raise capital in order to improve their financial situation. For example, Lang, Poulsen, and Stulz (1995) assert that firms sell assets not just to re-allocate assets to more efficient uses, but rather when doing so provides the cheapest source of funds. They argue that managers are 'reluctant to sell assets for efficiency reasons alone' assuming that size and control are valuable elements for them. Instead, management is motivated by the firm's constrained financial situation, as indicated by the firm's high leverage and poor performance prior to the sale. Accordingly, we employ two alternative proxies for financial need: firm leverage (*LEVERAGE*) and operating return on sales (*ROS*). Both of these measures are intended to capture a positive relationship between the need for external funds and the probability of divestiture. *ROS* is calculated as a two-year average of the ratio of operating income before depreciation to net sales. *LEVERAGE* is as defined in Section 5.3.

Another factor that may influence a firm's decision to divest its assets is the extent of information asymmetry about the firm. In the presence of asymmetric information, firms that need financing may find it expensive to go to the external capital markets due to the adverse selection problem modeled in Myers and Majluf (1984). To the extent that there is less information asymmetry about a firm's specific assets than about the entire firm, managers may prefer to sell a division instead of raising funds in the capital markets. In the case of equity carve-outs, for example, Nanda's (1991) model predicts that firms choosing carve-out transactions are those whose overall assets are undervalued while their subsidiary assets are overvalued. We use three different proxies for asymmetric information conventionally employed in the literature: analysts' earnings forecast error, forecast dispersion, and the number of analysts following a firm (e.g., see Krishnaswami and Subramaniam (1999) and Thomas (2002)). Firms with higher degrees of information asymmetry between insiders and other market participants are expected to have higher levels of forecast errors, more disagreement among analysts about their future earnings and to be followed by fewer analysts. Forecast error, *ERROR*, is measured as the absolute difference between the actual earnings and the median forecasted earnings. Forecast dispersion, *DISPERSION*, is the standard deviation of all analysts' estimates of earnings made in the same period. Both measures are scaled by the stock price in the current period. In estimating these measures, we utilize earnings forecasts that are made in the latest available month of the fiscal year.[28] Krishnaswami and Subramaniam (1999) note, however, that high forecast errors may be associated with volatile earnings rather than indicate the lack of public information about a firm. To address this possibility, we use the number of analysts following a firm, *N. ANALYSTS*, as an alternative measure of asymmetric information. Data on analysts' earnings forecasts are obtained from I/B/E/S.

Other control variables are *FIRM SIZE* and *SEGMENT SIZE*. Ravenscraft and Scherer (1987) provide evidence that a firm's high market share in a particular industry, which is correlated with segment size, retards divestiture of its segment in that industry. One reason may be that management perceives a high market share to be a competitive advantage and thus strives to preserve it. An opposite size effect at the firm level is that larger firms are simply more likely to divest their assets. Variables *FIRM SIZE* and *SEGMENT SIZE* are as defined in Section 5.3.

Finally, we include industry growth to control for various considerations that firms may have in rapidly growing industries. Operating in a growing industry may present current and future opportunities for a firm and, as a result, make managers less willing to part with industry-specific assets due to an increasing option value associated with those assets. A contrasting argument is provided in Maksimovic and Phillips (2001). They show that the probability of selling assets that are less productive than their industry benchmark is higher when the industry is undergoing a positive demand shock. They

[28] Elton, Gruber and Gultekin (1984) demonstrate that forecast errors tend to steadily decline over a forecasting period. More importantly, forecast errors are increasingly driven by misestimation of firm-specific factors, rather than systematic factors, as predictions are made closer to the end of the forecasting period.

conjecture that a positive demand shock results in higher opportunity costs for less productive firms in that industry.

Using data from the LRD, we calculate the industry-growth variable, *IND. GROWTH,* as the annualized compound growth rate (i.e., geometric average) of the industry's real total value added at the two-digit SIC level over the previous three years. In order to avoid spurious changes in the total value added from year to year due to incomplete coverage of establishments in non-census years, we use an average of total values added of all available establishments in an industry (as opposed to the sum of their total values added). We also weigh total values added of establishments by the so-called Sample Weight, which is a factor used by the Census Bureau to estimate aggregates for non-census years.[29] To generate an establishment's total value added, we first convert its total value of shipments, including resales and miscellaneous receipts, into the total value of output (i.e., production) by adjusting for the net change in finished goods and work-in-process inventories.[30] Next we subtract the total cost of materials consumed or put into production from the total value of output.[31] To obtain the *real* value added, the value of output and the cost of materials in current dollars are first deflated by an industry-specific output deflator and materials deflator, respectively. Industry price deflators at the three-digit SIC level for years 1997-2000 are obtained from an unpublished series of price indexes prepared by the Office of Productivity and Technology at the Bureau of Labor Statistics (BLS).[32] For years 1972-1996, we create output and materials deflators at the three-digit SIC level (equals 1.00 in 1987) from four-digit-SIC price deflators provided in

[29] These weights, as reported in the LRD, are equal to the reciprocal of the probability of being included into the Annual Survey of Manufactures (ASM). Thus, smaller establishments receive larger weights in order to compensate for their incomplete representation in ASM years.

[30] According to the LRD documentation, in some industries "differences in production and inventory behavior" result in the total value of shipments for establishments in those industries to be recorded as a metric that is more closely aligned with value of production rather than value of shipments. We make necessary adjustments in estimating the total value of production in such industries by dropping changes in one or both inventory terms.

[31] The total cost of materials as recorded in the LRD is already adjusted for materials withdrawn from inventories or received from other establishments of the same firm during the year, so no further adjustments are necessary.

[32] These output and materials deflators are created by the BLS for use in their labor productivity and multifactor productivity measures. The deflators are constructed mainly using detailed Producer Price Indexes (PPI) from the BLS Producer Price Index program. For more details on the methodology used in calculating these price deflators, see the *BLS Handbook of Methods* (available at http://www.bls.gov/opub/hom/homtoc.htm).

the National Bureau of Economic Research (NBER) Manufacturing Productivity Database (a.k.a. the Bartelsman-Becker-Gray Database).[33, 34]

Accordingly, we specify the Probit regression, with the dependent variable set equal to one if the segment is divested in the next year and equal to zero otherwise, as follows:

$$DIVESTITURE_{jit+1} = \gamma_0 + \gamma_1\, EFFICIENCY_{jit} + \gamma_2\, FIN.\ NEED_{it} + \gamma_3\, INFO.\ ASYMMETRY_{it} + \gamma_4\, SEGMENT\ SIZE_{jit} + \gamma_5\, FIRM\ SIZE_{it} + \gamma_6\, IND.\ GROWTH_{jt} + \varepsilon_{jit}, \quad (4)$$

where

$DIVESTITURE_{jit+1}$	= 1 if segment j of firm i is divested in year t+1, = 0 otherwise.
$EFFICIENCY_{jit}$	= Measure of efficiency of segment j of firm i in year t, as defined in Section 5.1.
$FIN.\ NEED_{it}$	= Measure of firm i's financial need in year t.
$INFO.\ ASYMMETRY_{it}$	= Measure of asymmetric information associated with firm i in year t.
$SEGMENT\ SIZE_{jit}$	= The natural logarithm of the number of establishments firm i operates within segment j in year t.
$FIRM\ SIZE_{it}$	= The natural logarithm of firm i's total assets in year t.
$IND.\ GROWTH_{jt}$	= The annualized compound growth rate of real total value added over the previous three years for segment j's industry.

The sample for this model contains 29,355 segment-years and covers the 1976-1998 period.[35] Table 11 presents estimation coefficients for different regression

[33] The NBER-CES Manufacturing Productivity Database is prepared by the NBER and the Census Bureau's Center for Economic Studies (CES). In summary, their output and materials deflators are calculated from five-digit product deflators available from the BEA, which in turn are based on Bureau of Labor Statistics' industry-specific producer indexes. I-O tables are then used to estimate four-digit price deflators based on the share of each industry's make or purchase of a particular product. For a detailed description of the database, see Bartelsman and Gray (1996).

[34] Three-digit output (materials) deflators are estimated by averaging corresponding four-digit output (materials) deflators, with the weights based on the relative share of each four-digit industry in the total value of shipments (cost of materials) of the three-digit industry.

specifications of the model. The coefficient on the variable *EFFICIENCY* indicates that efficiency is positively and statistically significantly related to a segment's subsequent sale. Given the finding in the previous section, it appears that assets that are being sold in the market are predominantly well-performing. This result also implies that firms tend to retain inefficient businesses. If managers act in the best interest of their shareholders, then inefficient corporate assets should be re-allocated to more efficient uses. There is evidence from spin-off studies that focus-increasing activities tend to add value. For example, Daley, Mehrotra, and Sivakumar (1997) find that a parent usually enjoys performance improvements when it spins off an entity. Therefore, the finding that firms retain inefficient divisions may suggest that managers are primarily concerned with 'building empires.' However, the observed positive relationship between segments' efficiency and their sale does not imply that managers hold on to divisions *regardless* of their performance, which would be more in line with the 'empire-building' behavior. A plausible reason why firms may be less willing to sell inefficient divisions is that it is somewhat harder to obtain a fair value for less productive assets since outsiders may be uncertain about the exact nature of inefficiency.

As predicted, leverage, which is a measure of financial constraint, positively affects segments' likelihood of divestiture. This relationship is statistically significant at the 1-percent level in all regression specifications. However, the effect of asymmetric information about a firm on its segment's sale is not robust to alternative proxies for asymmetric information. Consistent with the information-asymmetry explanation for asset sales by firms in need of financing, both the *ERROR* and *DISPERSION* variables are positive in all regression specifications, although not always statistically significant. If there is a high degree of information asymmetry about the entire firm, managers may prefer to sell a division instead of raising funds in the capital markets. On the other hand, the number of analysts following a firm (which is inversely related to the level of information asymmetry about the firm) is predicted to have a slightly positive effect on segment divestiture. However, the coefficient on the *N. ANALYSTS* variable is positive at only the 10-percent significance level.

[35] The sample period ends in the year 1998 because we do not include any observations in the last year of the LBD, which is the year 1999. A firm's final data point in the time series does not allow us to infer whether the firm divested a segment or simply ceased to exist (e.g., due to bankruptcy or takeover).

We also find strong evidence that the probability of a segment being divested increases when this segment is small. Finally, a positive sign, which is statistically significant at 5-percent level across all the regression specifications, on the *IND. GROWTH* variable suggests that divisions are more likely to change ownership if they are in expanding industries. This does not support the argument that managers have a tendency to hold on to assets in growing industries in order to retain the option value of those assets.

In columns (7) and (8) of Table 11, we include the firm diversification variable, the horizontal and vertical relatedness variables, and the firm efficiency variable as additional regressors. In the new specifications, coefficients on all other variables remain qualitatively the same with one exception. The firm size variable became statistically significant and negative, indicating that smaller firms have a higher propensity to sell their segments than larger firms, which in turn are more likely to acquire segments (from Table 10).

Divisions that are not horizontally-related to other businesses within the same firm are more likely to be divested. Taken together with the observation that segment size and divestitures have a negative relationship, this can be seen as the manifestation of focus-increasing activities, where firms let go small non-core businesses. Surprisingly, firms also tend to sell vertically-related segments. Finally, we find that more efficient firms are less likely to part with their assets. Recall that such firms also tend to be acquirers, as discussed in the previous section. Thus, we conclude that firms re-allocate assets from less efficient users to those that have a better ability to manage them.

7. Conclusion

Our study contributes to the literature on corporate diversification by empirically testing cost/benefit implications of operating multi-segment firms in comparison to single-segment firms. We carry out our tests using plant-level data for a large sample of firms that operate in the U.S. manufacturing sector. The data provide detailed input/output information that was compiled by the U.S. Census Bureau. To estimate efficiency, we employ a test based on the Weak Axiom of Profit Maximization. Apart from its computational simplicity, the WAPM test provides several advantages over other conventional methods of estimating productive efficiency, such as no imposition of any particular functional form on the data.

We find that diversification leads to more efficient segments when efficiency is compared among firms operating in the same industry. Moreover, within-firm vertical integration of segments further contributes to segment efficiency. On the other hand, size both at the segment and firm levels tends to reduce efficiency. When relative productive performance of internally-grown and acquired segments is compared, acquired segments appear to have superior performance. We also find that segments with a higher level of efficiency are more likely to be transferred between market participants. When businesses change ownership, more efficient firms tend to be buyers and less efficient firms tend to be sellers. Taken together, our findings provide evidence in support of the view that synergy is one of the driving factors in pursuing corporate diversification. We find no conclusive support for the agency-costs explanation of diversification.

Our and Schoar's (2002) finding that diversification leads to efficiency gains contradicts implications of the diversification discount found in the earlier literature on corporate diversification. One possible explanation of this discrepancy may be that the discount is a result of measurement error. Villalonga (2004), for example, maintains that the discount is 'an artifact of segment data.' Consistent with the argument, the author demonstrates that using an alternative data source results in the 'diversification premium' for the same exact sample that produces a discount using COMPUSTAT Segment files. Another explanation, which does not refute the existence of the diversification discount, may be that the gains from efficiency improvements alone do not necessarily offset the costs associated with agency conflicts within a firm. For instance, if management expropriates most of the gains resulted from superior production performance, shareholders might not reap all benefits from these gains. Hence, it is still possible to observe a discount associated with market values of diversified firms even if such firms tend to be more efficient compared to their focused counterparts. Whether benefits from superior productive performance in diversified firms accrue to their shareholders or to their management is an empirical question to be pursued in future research.

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Appendix

Robustness Checks

1. Purchased Services

Plants differ in the way they perform business and other services. Even though most plants execute such services using their own labor force, a number of plants tend to outsource some of those services. Choosing to purchase services from other companies may be driven by plants' lack of expertise in performing them and/or cost considerations. Not taking into account the cost of purchased services may bias our results as the cost of such services for those plants that perform them in-house is reflected in their wage bill.

The LRD provides data on purchased services for the years 1992 and 1997 only. Information is available on costs of purchased business services (i.e., accounting and bookkeeping services, legal services, advertising, communications services, and software) and other production-related services (i.e., repair of buildings, structures and machinery, and refuse removal). As a robustness check, we include the cost of purchased services in calculating plant efficiency and then re-estimate regression (1) for the years 1992 and 1997. We group all purchased business services into a separate input category. The quantity of business services is the number of people it takes to perform these services during a year, estimated by dividing the total cost of purchased business services by the price of the services. The price of purchased business services is approximated by the average annual salary for SIC code 7389, *Business Services*, in the state where the plant is located.[36] Purchased production-related services—those for repair of assets and refuse removal—are incorporated into the production labor input. The quantity of purchased production services is the number of equivalent non-production employees, calculated as the reported cost of outsourced production services divided by the price of the services. The price is the average wage rate for production-worker man-hour, where the average wage rate is estimated across all plants in the same four-digit SIC code, state, and year. The quantity of purchased production services is then added to the quantity of production labor. Finally, the price of production labor is adjusted by taking a weighted average of the price of the plant's own production labor and that of the purchased production services, with weights based on the corresponding quantities.

[36] The wage data are obtained from the U.S. Department of Labor.

After incorporating purchased business services into plants' cost structure, our main results discussed in Section 6.2.1 remain qualitatively unchanged.[37] In particular, we find that segment efficiency continues to be increasing in the degree of firm diversification.

2. Services Performed at Auxiliary Establishments

Another limitation of using the LRD alone for studying diversification implications on efficiency is that it does not contain data on auxiliary establishments located offsite, such as headquarters and other non-production facilities. Large firms with multiple establishments may have the propensity to centralize administrative, sales, and other functions away from their individual establishments in an attempt to reduce overhead. If these firm-level costs are significant, then any measure of segment productivity that does not capture these costs would be distorted.[38] From the table presented below, one can see that almost half of our sample firms with operations in the manufacturing sector reported performing some services offsite in at least one of the census years (excluding the year 1997). More importantly, it appears that especially multi-segment firms tend to consolidate their administrative, marketing, research, and other functions common to all their business divisions at auxiliary facilities. Approximately 58 percent of sample diversified firms versus only 18 percent of focused firms reported having some services done at auxiliary facilities.

	Focused firms	**Diversified firms**	**Total**
Total number of firms	668	2,147	2,815
Firms with offsite auxiliary facilities	123	1,252	1,332
Proportion of firms with auxiliary facilities	18.41%	58.31%	47.32%

Data source: The Auxiliary Establishment Survey, 1977, 1982, 1987, 1992

[37] These regression results are not reported here, but available on request.

[38] A constantly growing ratio of administrative personnel to production workers suggests that the magnitude of these costs is not trivial. Lichtenberg (1992a) reports that the number of employees in auxiliaries of manufacturing firms increased by 325 percent between 1947 and 1982, whereas the number of workers on the shop floor increased by only 20 percent in the same time period.

Thus, not accounting for costs associated with services performed offsite may bias our study towards finding diversified firms to be more efficient relative to their focused counterparts.

To rule out this possibility, we supplement cost data for production establishments with data on costs incurred by their auxiliary facilities, which are available from the U.S. Census Bureau's Auxiliary Establishment Survey (AES) in census years. Due to a change in data presentation in the AES and concurrent poor documentation of it in the year 1997, we exclude that year from the robustness test. The AES provides an SIC code for each auxiliary establishment. This industry affiliation indicates an industry of production plants that the auxiliary facility serves. Using this industry information, we aggregate expenses reported by auxiliary establishments—labor, stock of physical capital, business services, and other expenses—to the firm's segment level. We then allocate a share of this corporate overhead to firms' plants based on their contribution to the business segment's total output.

In the census years 1977, 1982, 1987, and 1992, 1,332 firms with manufacturing operations in our sample had some services performed at auxiliary facilities. Using re-estimated segment efficiency that incorporates costs of those services, we repeat the regression analysis. The results of regression (1) do not change materially.[39] Business segments of conglomerates continue to be more efficient compared to single-segment firms in the same industry even after taking into account costs incurred by diversified firms away from their production plants.

[39] These regression results are not reported here, but available on request.

Table 1
Variable Description and Data Sources

Variable Name	Description	Data Source
Dependent Variables		
EFFICIENCY	Segment efficiency computed as one minus the weighted average of the segment's establishments' failure rates. The weights are based on the share of the total value of shipments. An establishment's failure rate is the ratio of the number of other establishments that dominate the establishment using the Weak Axiom of Profit Maximization test to the number of all establishments with outputs greater than that of the establishment.	Longitudinal Research Database, Bureau of Labor Statistics
DIVESTITURE	=1 if the segment is divested in the next year; = 0 otherwise.	Longitudinal Business Database
Independent Variables		
HERF	One minus the firm's Herfindahl Index based on its total employment at the two digit SIC level. Total employment is defined as the average number of production workers over four payroll periods during the year plus the number of non-production personnel employed during the pay period that includes March 12.	Longitudinal Business Database
log (NUMSEG)	The natural logarithm of the number of a firm's segments at the two-digit SIC level.	Longitudinal Business Database
H.RELAT DUMMY	= 1 if the segment is horizontally related to another segment of the same firm, and = 0 otherwise. Segments are defined at the two-digit SIC level and classified as horizontally related if they share a common one-digit SIC code.	Longitudinal Business Database
V.RELAT DUMMY	= 1 if the segment is vertically related to another segment of the same firm, and = 0 otherwise. Segments are defined at the two-digit SIC level. Segments within a firm are classified as vertically related if their corresponding industries receive (or supply) at least five percent of their inputs (outputs) from each other.	Longitudinal Business Database Input-Output Tables published by the Bureau of Economic Analysis

Table 1(continued)
Variable Description and Data Sources

Variable Name	Description	Data Source
ADDTYPE	= 1 if the segment is added through an acquisition, and = 0 if the segment is grown internally.	Longitudinal Business Database, COMPUSTAT Industrial Annual Research file, Securities Data Company (SDC)
SEGMENT SIZE	The natural logarithm of the number of establishments a firm operates with a common two-digit SIC code.	Longitudinal Business Database
FIRM SIZE	The natural logarithm of the firm's total assets.	COMPUSTAT Industrial Annual Research file
LEVERAGE	The firm's book value of total debt (current liabilities plus long-term debt) divided by the sum of the book value of total debt, the book value of preferred stock and the market value of equity. The variable is averaged over the current and previous years.	COMPUSTAT Industrial Annual Research file, Center for Research in Security Prices Database (CRSP)
PLANT AGE	The weighted average of numbers of years of operation by the segment's establishments, with the weights based on each establishment's total value of shipments.	Longitudinal Business Database
ROS	The ratio of operating income before depreciation to net sales. The variable is averaged over the current and previous years.	COMPUSTAT Industrial Annual Research file
ERROR	The absolute difference between the actual earnings and the median analysts' forecasted earnings.	I/B/E/S Database
DISPERSION	The standard deviation of all analysts' estimates of earnings made in the same period.	I/B/E/S Database
N. ANALYSTS	The number of analysts following the firm.	I/B/E/S Database

Table 1(continued)
Variable Description and Data Sources

Variable Name	Description	Data Source
IND. GROWTH	The geometric average of the industry's real total value added at the two-digit SIC level over the previous three years.	Longitudinal Research Database, NBER Manufacturing Productivity Database
FIRM EFFICIENCY	Firm efficiency computed as one minus the weighted average of the firm's establishments' failure rates. The weights are based on the share of the total value of shipments. An establishment's failure rate is the ratio of the number of other establishments that dominate the establishment using the Weak Axiom of Profit Maximization test to the number of all establishments with outputs greater than that of the establishment.	Longitudinal Research Database, Bureau of Labor Statistics
Production Input/Output Quantities and Prices:		
MATERIALS: QUANTITY	Total cost of materials put into production during the year divided by the price of materials.	Longitudinal Research Database
MATERIALS: PRICE	Assumed to be constant across all establishments.	Longitudinal Research Database
PROD. LABOR: QUANTITY	Total man-hours during the year.	Longitudinal Research Database
PROD. LABOR: PRICE	Wage rate per man-hour.	Longitudinal Research Database
NON-PROD. LABOR:	Number of non-production employees during the pay period.	Longitudinal Research Database
NON-PROD. LABOR: PRICE	Annual salary per non-production employee.	Longitudinal Research Database
CAPITAL STOCK: QUANTITY	Total fixed assets, estimated using the perpetual inventory method.	Longitudinal Research Database
CAPITAL STOCK: PRICE	Capital expenditures divided by fixed assets.	Longitudinal Research Database
ELECTRICITY: QUANTITY	Number of kilowatt hours purchased or transferred from other establishments during the year.	Longitudinal Research Database
ELECTRICITY: PRICE	Cost per kilowatt hour.	Longitudinal Research Database
OUTPUT	Total value of shipments during the year, adjusted for annual changes in inventories of finished goods and work-in-progress.	Longitudinal Research Database

Table 2
Descriptive Statistics

The table reports descriptive statistics for the sample of 3,737 firms during the 1976-2000 period. Panel A and B present segment-level and firm-level statistics, respectively. Segments are defined at the two-digit SIC level. An establishment is a basic economic unit typically at a single physical location. Total employment is the average number of production workers over four payroll periods during the year plus the number of non-production personnel employed during the pay period that includes March 12. Total assets at the firm level are obtained from the COMPUSTAT Industrial Annual Research files. The rest of the statistics are based on the data from the Longitudinal Research Database and the Longitudinal Business Database.

Panel A: Segment-Level Statistics

Time Period	Number of Segment-Years	Number of Establishments		Total Value of Shipments (in $millions)		Total Employment	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1976-1980	13,219	7.94	13.31	211.53	795.29	2,105.36	5,344.61
1981-1985	14,634	7.62	13.27	274.63	1,038.26	1,825.20	4,868.62
1986-1990	12,101	7.55	13.50	381.02	1,903.09	1,912.49	6,776.56
1991-1995	12,661	7.33	14.47	450.95	1,950.00	1,754.38	5,106.53
1996-2000	9,040	7.83	14.87	670.05	2,707.45	2,000.55	5,848.94
1976-2000	61,655	7.65	13.82	376.17	1,726.21	1,913.57	5,581.07

Panel B: Firm-Level Statistics

Time Period	Number of Firm-Years	Number of Establishments		Total Assets (in $millions)		Total Employment		Number of Segments	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
1976-1980	5,826	19.71	30.23	581.53	2,121.49	4,941.90	11,336.81	6.18	5.36
1981-1985	7,280	16.80	28.33	773.84	2,943.91	3,788.67	9,539.12	5.71	5.17
1986-1990	6,439	15.45	25.00	1,179.21	4,681.82	3,839.36	13,335.88	5.16	4.47
1991-1995	6,918	14.10	25.07	1,845.78	8,640.19	3,367.95	9,330.13	4.55	3.93
1996-2000	5,594	13.80	24.26	2,752.46	12,007.97	3,386.91	9,336.22	3.96	3.26
1976-2000	32,057	15.95	26.77	1,396.91	7,002.65	3,847.54	10,678.56	5.13	4.59

Table 3

Number of Firm-Years by Number of Segments

The table presents the distribution of firm-years across the number of business segments. The sample consists of 32,057 firm-years that represent 3,737 firms during the 1976-2000 period. Segments are defined at the two-digit SIC level.

Number of Segments	Number of Firm-Years	Percentage
1	4,557	14.22%
2	5,786	18.05%
3	4,975	15.52%
4	3,820	11.92%
5	2,824	8.81%
6	2,014	6.28%
7	1,630	5.08%
8	1,193	3.72%
9	926	2.89%
10	761	2.37%
11	685	2.14%
12	507	1.58%
13	462	1.44%
14	336	1.05%
15-19	1,030	3.21%
>20	551	1.72%
Total	32,057	100.00%

Table 4
Descriptive Statistics by Industry

The table presents descriptive statistics by two-digit SIC code. The sample is comprised of 61,655 segment-years that represent 3,737 firms during the 1976-2000 period. Segments are defined at the two-digit SIC level. An establishment is a basic economic unit typically at a single physical location.

Two-digit SIC Code	SIC Description	Segment-Years		Number of Establishments per Segment		Proportion of Focused Firms
		Number	Percentage	Mean	Std. Dev.	
20	Food and kindred products	3,061	5.0%	16.57	26.26	6.99%
21	Tobacco manufactures	199	0.3%	6.92	4.82	3.02%
22	Textile mill products	1,823	3.0%	7.65	12.52	4.44%
23	Apparel and other textile products	1,674	2.7%	8.42	14.49	6.33%
24	Lumber and wood products	2,038	3.3%	11.74	18.94	5.45%
25	Furniture and fixtures	1,489	2.4%	5.31	7.26	6.65%
26	Paper and allied products	1,714	2.8%	17.84	26.70	3.03%
27	Printing and publishing	2,435	3.9%	12.53	19.54	7.10%
28	Chemicals and allied products	4,605	7.5%	11.61	18.60	6.73%
29	Petroleum and coal products	1,113	1.8%	8.80	13.90	1.62%
30	Rubber and miscellaneous plastics products	2,759	4.5%	5.81	6.32	5.73%
31	Leather and leather products	630	1.0%	5.47	6.84	6.35%
32	Stone, clay, glass, and concrete products	2,451	4.0%	10.03	14.88	2.20%
33	Primary metal industries	3,841	6.2%	5.48	11.56	3.67%
34	Fabricated metal products	6,229	10.1%	5.88	7.57	2.38%
35	Industrial machinery and equipment	8,282	13.4%	5.35	8.06	8.98%
36	Electrical and other electronic equipment	7,388	12.0%	5.49	9.56	16.54%
37	Transportation equipment	3,541	5.7%	6.52	11.87	2.85%
38	Instruments and related products	4,535	7.4%	4.15	5.53	14.91%
39	Miscellaneous manufacturing industries	1,848	3.0%	3.55	3.47	5.57%
Total		61,655	100.0%	7.65	13.82	14.22%

Table 5
Statistical Properties of Segment Efficiency

Panel A: Descriptive Statistics for Segment Efficiency by Period

The panel reports descriptive statistics for segment efficiency for the sample of 61,655 segment-years that represent 3,737 firms during the 1976-2000 period. The efficiency measure is bounded between zero and one, where one (zero) indicates a fully efficient (inefficient) segment based on the Weak Axiom of Profit Maximization test. For more details on the definition of the measure of efficiency see Table 1.

Time Period	Number of Segment-Years	Mean	Standard Deviation
1976-1980	13,219	0.89	0.13
1981-1985	14,634	0.88	0.14
1986-1990	12,101	0.87	0.15
1991-1995	12,661	0.89	0.14
1996-2000	9,040	0.88	0.15
1976-2000	61,655	0.88	0.14

Table 5(continued)
Statistical Properties of Segment Efficiency

Panel B: Stability of Segment Efficiency: 1977-1997

This panel provides statistics about the stability of segments' efficiency over time. At the beginning and end of each five-year period, all sample segments are ranked based on their efficiency within their two-digit SIC codes and grouped into quintiles, where group 1 contains the most efficient segments and group 5 contains the least efficient segments. A value in the table shows the number of firm segments, as well as the corresponding percentage of those segments, that transitioned from the column group to the row group over a given period. The last column contains the number of firm segments that are not present in the sample at the end of the period.

	Number of Observations	1	2	3	4	5	Missing Observations
				Period: 1977-1982			
1	563	168 39.16%	92 21.45%	59 13.75%	50 11.66%	60 13.99%	134
2	564	68 15.78%	129 29.93%	121 28.07%	68 15.78%	45 10.44%	133
3	572	45 9.76%	82 17.79%	138 29.93%	115 24.95%	81 17.57%	111
4	566	35 7.63%	62 13.51%	113 24.62%	134 29.19%	115 25.05%	107
5	558	30 6.96%	38 8.82%	54 12.53%	111 25.75%	198 45.94%	127
				Period: 1982-1987			
1	742	108 34.73%	68 21.86%	52 16.72%	46 14.79%	37 11.90%	431
2	750	82 25.95%	82 25.95%	75 23.73%	45 14.24%	32 10.13%	434
3	749	40 11.40%	81 23.08%	87 24.79%	93 26.50%	50 14.25%	398
4	752	28 8.28%	44 13.02%	81 23.96%	96 28.40%	89 26.33%	414
5	738	41 10.99%	46 12.33%	45 12.06%	92 24.66%	149 39.95%	365
				Period: 1987-1992			
1	526	104 38.52%	56 20.74%	40 14.81%	37 13.70%	33 12.22%	256
2	531	44 14.33%	92 29.97%	94 30.62%	51 16.61%	26 8.47%	224
3	532	38 11.34%	72 21.49%	102 30.45%	75 22.39%	48 14.33%	197
4	533	34 10.03%	42 12.39%	64 18.88%	100 29.50%	99 29.20%	194
5	523	36 11.21%	30 9.35%	52 16.20%	64 19.94%	139 43.30%	202

Table 5(continued)
Sample Characteristics of Segment Efficiency

Panel B: Stability of Segment Efficiency: 1977-1997 (continued)

	Number of Observations	1	2	3	4	5	Missing Observations
				Period: 1992-1997			
1	657	131 42.53%	70 22.73%	45 14.61%	27 8.77%	35 11.36%	349
2	662	69 20.91%	100 30.30%	73 22.12%	56 16.97%	32 9.70%	332
3	668	46 12.17%	83 21.96%	110 29.10%	89 23.54%	50 13.23%	290
4	663	41 11.39%	46 12.78%	90 25.00%	104 28.89%	79 21.94%	303
5	652	42 12.96%	28 8.64%	44 13.58%	73 22.53%	137 42.28%	328
				Overall Period: 1977-1997			
1	563	34 28.33%	24 20.00%	21 17.50%	19 15.83%	22 18.33%	443
2	564	26 17.57%	23 15.54%	42 28.38%	33 22.30%	24 16.22%	416
3	572	19 12.75%	30 20.13%	26 17.45%	39 26.17%	35 23.49%	423
4	566	21 13.55%	26 16.77%	35 22.58%	45 29.03%	28 18.06%	411
5	558	17 12.41%	26 18.98%	24 17.52%	28 20.44%	42 30.66%	421

Table 6

Univariate Analysis: Focused versus Diversified Firms

The table presents descriptive statistics at the plant level and segment level in Panel A and Panel B, respectively. Corresponding statistics along with t-tests for the difference in means are provided for the sample of stand-alone firms and the sample of diversified firms. The full sample contains 3,737 firms over the 1976-2000 period for a total of 252,871 plant-years and 61,655 segment-years. Definitions of the variables are available in Table 1. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively.

Variable	Full Sample		Focused		Diversified		Test Statistic: $\mu_f=\mu_d$
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Panel A: Plant-Level Statistics							
PLANT AGE	13.18	6.98	13.49	7.91	13.17	6.95	3.50 ***
TOTAL VALUE OF SHIPMENTS (in $millions)	81.83	298.57	53.17	149.31	82.73	302.05	-16.42 ***
TOTAL EMPLOYMENT	416.72	1,025.07	332.10	519.14	419.40	1,036.95	-13.96 ***
Production Variables :							
MATERIALS: QUANTITY (in million)	41.78	190.78	23.07	65.92	42.37	193.40	-22.87 ***
PROD. LABOR: QUANTITY (in manhours)	563,056.98	1,206,626.29	434,461.93	714,046.70	567,128.73	1,218,755.59	-15.66 ***
PROD. LABOR: PRICE ($)	13.95	7.74	14.24	8.46	13.94	7.71	3.03 ***
NON-PROD. LABOR: QUANTITY (in employees)	136.26	538.78	117.89	256.70	136.84	545.32	-6.08 ***
NON-PROD. LABOR: PRICE ($)	39,467.49	26,263.54	44,367.13	25,519.29	39,312.35	26,271.90	17.16 ***
CAPITAL STOCK: QUANTITY (in $millions)	70.39	485.00	56.02	253.17	70.85	490.55	-4.88 ***
CAPITAL STOCK: PRICE	0.11	5.34	0.10	0.25	0.11	5.42	-1.31
ELECTRICITY: QUANTITY (in gigawatt hours)	22.48	96.08	11.60	55.62	22.82	97.07	-16.98 ***
ELECTRICITY: PRICE ($)	0.07	1.03	0.07	0.43	0.07	1.04	0.62
OUTPUT (in $millions)	82.08	299.42	53.36	150.02	82.99	302.91	-16.37 ***
Number of Plant-Years	N=252,871		N=7,761		N=245,110		
Panel B: Segment-Level Statistics							
NUMBER OF PLANTS	7.65	13.82	2.85	3.82	8.03	14.25	-63.01 ***
TOTAL VALUE OF SHIPMENTS (in $millions)	376.17	1726.21	102.80	316.61	397.98	1789.75	-33.40 ***
TOTAL ASSETS (in $millions)	91.87	458.95	15.52	45.54	97.97	476.21	-39.19 ***
TOTAL EMPLOYMENT	1913.57	5581.07	631.51	1118.82	2015.89	5778.65	-47.22 ***
EFFICIENCY	0.88	0.14	0.89	0.14	0.88	0.14	3.78 ***
Number of Segment-Years	N=61,655		N=4,557		N=57,098		

Table 7
The Effect of Diversification on Efficiency

The table reports estimation results for Tobit regressions of diversification on segment efficiency for a sample of firm segments over the 1976-2000 period. The estimated coefficients are from regression specifications of the following equation (1):

$$EFFICIENCY_{jit} = \alpha_0 + \alpha_1\, DIV_{it} + \alpha_2\, H.\ RELAT_{jit} + \alpha_3\, V.\ RELAT_{jit} + \alpha_4\, DIV_{it} \times H.\ RELAT_{jit} + \alpha_5\, DIV_{it} \times V.\ RELAT_{jit} + \alpha_6\, SEGMENT\ SIZE_{jit} + \alpha_7\, FIRM\ SIZE_{it} + \alpha_8\, LEVERAGE_{it} + \alpha_9\, PLANT\ AGE_{jit} + \varepsilon_{jit},$$

where the dependent variable is segment efficiency. The efficiency measure is bounded between zero and one, where one (zero) indicates a fully efficient (inefficient) segment based on the Weak Axiom of Profit Maximization test. DIV represents a measure of firm diversification, proxied by either the employment-based Herfindahl Index, HERF, or the natural logarithm of the number of the firm's segments, log(NUMSEG). Both variables HERF and log(NUMSEG) are mean-centered. Detailed definitions of these and other variables are available in Table 1. T-statistics are reported in parentheses. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively.

	Diversification measure: HERF		Diversification measure: log (NUMSEG)		Additional specifications	
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept	1.052 ***	1.052 ***	1.093 ***	1.098 ***	0.115 ***	0.149 ***
	(119.39)	(112.93)	(102.84)	(100.00)	(5.57)	(6.80)
HERF	0.014 **	0.025 ***			0.035 ***	
	(2.39)	(4.08)			(3.82)	
log *(NUMSEG)*			0.007 ***	0.011 ***		0.022 ***
			(3.15)	(5.12)		(5.34)
H.RELAT DUMMY	0.003	-0.002	0.002	-0.003	0.003	0.002
	(1.58)	(0.86)	(1.21)	(1.49)	(0.57)	(0.26)
V.RELAT DUMMY	0.008 ***	0.004 *	0.008 ***	0.003	-0.012 ***	-0.027 ***
	(3.55)	(1.69)	(3.02)	(1.00)	(2.98)	(3.82)
HERF × H. RELAT DUMMY	-0.030 ***	-0.032 ***			0.007	
	(4.60)	(4.90)			(0.51)	
HERF × V. RELAT DUMMY	0.031 ***	0.024 ***			-0.053 ***	
	(4.09)	(3.13)			(3.77)	
log *(NUMSEG) × H. RELAT DUMMY*			-0.008 ***	-0.008 ***		0.007
			(3.14)	(3.15)		(0.85)
log *(NUMSEG) × V. RELAT DUMMY*			0.012 ***	0.009 ***		-0.025 ***
			(3.90)	(2.88)		(3.23)
SEGMENT SIZE	-0.005 ***	-0.004 ***	-0.005 ***	-0.005 ***	-0.005 ***	-0.005 ***
	(8.39)	(7.52)	(9.02)	(8.05)	(4.50)	(4.29)
FIRM SIZE	-0.006 ***	-0.006 ***	-0.008 ***	-0.009 ***	-0.001	-0.002 **
	(16.76)	(17.97)	(18.14)	(19.80)	(1.51)	(2.37)
LEVERAGE	-0.017 ***	-0.021 ***	-0.019 ***	-0.022 ***	0.004	0.003
	(6.09)	(7.41)	(6.72)	(8.07)	(1.13)	(0.82)
PLANT AGE	-0.002 ***	-0.002 ***	-0.002 ***	-0.002 ***	-0.001 ***	-0.001 ***
	(12.78)	(13.93)	(12.74)	(13.85)	(4.79)	(4.77)
FIRM EFFICIENCY					0.907 ***	0.906 ***
					(109.36)	(109.40)

Table 7(continued)
The Effect of Diversification on Efficiency

Variable	Diversification measure: HERF (1)	(2)	Diversification measure: log (NUMSEG) (3)	(4)	Additional specifications (5)	(6)
FIRM EFFICIENCY $_{t-1}$					0.010	0.008
					(1.05)	(0.91)
FIRM EFFICIENCY $_{t-2}$					0.002	0.002
					(0.24)	(0.20)
Number of observations	61,655	61,655	61,655	61,655	7,280	7,280
2-digit SIC Dummies	No	Yes	No	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes

Table 8
The Effect of Diversification and Method of Segment Addition on Efficiency

The table presents estimation results for Tobit regressions of diversification and the method of segment addition on segment efficiency for a sample of firm segments over the 1977-2000 period. The sample contains only observations for segments in the three-year period after their addition to the firm. The estimated coefficients are from regression specifications of the following equation (2):

$$EFFICIENCY_{jit} = \beta_0 + \beta_1 \, DIV_{it} + \beta_2 \, ADDTYPE_{ji\,[t-3,\,t]} + \beta_3 \, H.\ RELAT_{jit} + \beta_4 \, V.\ RELAT_{jit} + \beta_5 \, SEGMENT\ SIZE_{jit} + \beta_6 \, FIRM\ SIZE_{it} + \beta_7 \, LEVERAGE_{it} + \beta_8 \, PLANT\ AGE_{jit} + \varepsilon_{jit},$$

where the dependent variable is segment efficiency. The efficiency measure is bounded between zero and one, where one (zero) indicates a fully efficient (inefficient) segment based on the Weak Axiom of Profit Maximization test. *DIV* represents a measure of firm diversification, proxied by either the employment-based Herfindahl Index, *HERF*, or the natural logarithm of the number of the firm's segments, *log* (*NUMSEG*). Detailed definitions of these and other variables are available in Table 1. T-statistics are reported in parentheses. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively.

	Diversification proxy: HERF		Diversification proxy: log (NUMSEG)		Additional specifications	
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept	1.048 ***	1.025 ***	1.067 ***	1.053 ***	0.122 *	0.164 **
	(52.19)	(48.97)	(48.07)	(46.20)	(1.84)	(2.41)
HERF	0.022 ***	0.026 ***			-0.047 ***	
	(3.49)	(4.20)			(3.41)	
log (NUMSEG)			0.009 ***	0.012 ***		0.003
			(3.34)	(4.50)		(0.42)
ADDTYPE	0.008 ***	0.009 ***	0.009 ***	0.010 ***	0.016 **	0.014 *
	(2.64)	(3.04)	(2.76)	(3.17)	(2.32)	(1.94)
H.RELAT DUMMY	0.004	-0.001	0.004	-0.002	0.013	0.003
	(1.14)	(0.36)	(1.30)	(0.42)	(1.52)	(0.32)
V.RELAT DUMMY	0.009 **	0.006	0.008 **	0.005	0.007	0.001
	(2.23)	(1.55)	(1.98)	(1.15)	(0.85)	(0.10)
SEGMENT SIZE	-0.005 ***	-0.004 ***	-0.005 ***	-0.004 ***	-0.016 ***	-0.015 ***
	(3.32)	(2.77)	(3.37)	(2.78)	(4.49)	(4.02)
FIRM SIZE	-0.005 ***	-0.006 ***	-0.007 ***	-0.007 ***	0.000	-0.002
	(7.05)	(7.24)	(7.11)	(7.84)	(0.00)	(0.62)
LEVERAGE	-0.017 ***	-0.018 ***	-0.017 ***	-0.018 ***	0.002	-0.002
	(2.86)	(3.01)	(2.87)	(3.06)	(0.10)	(0.14)
PLANT AGE	-0.002 ***	-0.002 ***	-0.002 ***	-0.002 ***	-0.001 **	-0.001 **
	(6.38)	(7.26)	(6.40)	(7.28)	(2.29)	(2.16)
FIRM EFFICIENCY					0.846 ***	0.835 ***
					(30.68)	(30.29)
FIRM EFFICIENCY $_{t-1}$					-0.002	-0.005
					(0.10)	(0.17)
FIRM EFFICIENCY $_{t-2}$					0.028	0.030
					(1.03)	(1.11)
Number of observations	11,823	11,823	11,823	11,823	1,139	1,139
2-digit SIC Dummies	No	Yes	No	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes

Table 9
The Effect of Diversification on Efficiency: Internal versus External Segment Additions

The table presents estimation results for Tobit regressions of diversification on segment efficiency by method of segment addition for a sample of 1,139 firm-segments over the 1977-2000 period. The sample contains only observations for segments in the three-year period after their addition to the firm. The estimated coefficients are from regression specifications of the following equation:

$$EFFICIENCY_{jit} = \beta_0 + \beta_1\, DIV_{it} + \beta_2\, ADDTYPE_{ji\,[t-3,\,t]} + \beta_3\, H.\,RELAT_{jit} + \beta_4\, V.\,RELAT_{jit} + \beta_5\, SEGMENT\ SIZE_{jit} + \beta_6\, FIRM\ SIZE_{it} + \beta_7\, LEVERAGE_{it} + \beta_8\, PLANT\ AGE_{jit} + \beta_9\, DIV_{it} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{10}\, H.\,RELAT_{jit} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{11}\, V.\,RELAT_{jit} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{12}\, SEGMENT\ SIZE_{jit} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{13}\, FIRM\ SIZE_{it} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{14}\, LEVERAGE_{it} \times ADDTYPE_{ji\,[t-3,\,t]} + \beta_{15}\, PLANT\ AGE_{jit} \times ADDTYPE_{ji\,[t-3,\,t]} + \varepsilon_{jit},$$

where the dependent variable is segment efficiency. The efficiency measure is bounded between zero and one, where one (zero) indicates a fully efficient (inefficient) segment based on the Weak Axiom of Profit Maximization test. DIV represents a measure of firm diversification, proxied by either the employment-based Herfindahl Index, HERF, or the natural logarithm of the number of the firm's segments, log(NUMSEG). Detailed definitions of these and other variables are available in Table 1. The columns labeled 'Internal' contain estimation results for regressions with the *ADDTYPE* variable set equal to zero if the segment is grown internally and one if the segment is added externally. The columns labels 'External' have the *ADDTYPE* variable re-defined such that it is set equal to zero if the segment is added externally. All model specifications include industry (defined at the segment's two-digit SIC level) and year fixed effects. T-statistics are reported in parentheses. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively.

Variable	Diversification proxy: HERF			Diversification proxy: log (NUMSEG)		
	Internal	External	Difference	Internal	External	Difference
Intercept	0.125 *	0.125 *		0.152 **	0.152 **	
	(1.77)	(1.77)		(2.09)	(2.09)	
HERF	-0.063 ***	0.024	-0.087 ***			
	(4.15)	(0.80)	(2.63)			
log (NUMSEG)				-0.004	0.027 *	-0.031 *
				(0.49)	(1.77)	(1.85)
ADDTYPE	0.124	0.124		0.142	0.142	
	(1.05)	(1.05)		(1.17)	(1.17)	
H.RELAT DUMMY	0.021 **	-0.028	0.049 **	0.012	-0.033 *	0.046 **
	(2.32)	(1.39)	(2.30)	(1.29)	(1.68)	(2.12)
V.RELAT DUMMY	0.002	0.038 **	-0.037 **	-0.006	0.030 *	-0.037 **
	(0.17)	(2.34)	(2.03)	(0.67)	(1.79)	(1.97)
SEGMENT SIZE	-0.014 ***	-0.020 ***	0.006	-0.013 ***	-0.019 ***	0.006
	(3.48)	(2.85)	(0.72)	(3.17)	(2.63)	(0.69)
FIRM SIZE	0.001	-0.006	0.006	0.000	-0.008	0.008
	(0.33)	(1.13)	(1.18)	(0.00)	(1.62)	(1.45)
LEVERAGE	0.012	-0.034	0.046	0.007	-0.028	0.034
	(0.83)	(1.17)	(1.42)	(0.46)	(0.94)	(1.05)
PLANT AGE	-0.002 ***	0.000	-0.002 *	-0.002 ***	0.000	-0.002 *
	(2.82)	(0.00)	(1.84)	(2.73)	(0.24)	(1.93)
FIRM EFFICIENCY	0.872 ***	0.773 ***	0.099	0.859 ***	0.771 ***	0.088
	(27.99)	(13.23)	(1.50)	(27.53)	(13.12)	(1.32)
FIRM EFFICIENCY $_{t-1}$	-0.007	0.002	-0.009	-0.012	0.002	-0.014
	(0.22)	(0.00)	(0.14)	(0.39)	(0.00)	(0.20)
FIRM EFFICIENCY $_{t-2}$	0.007	0.077	-0.070	0.009	0.075	-0.066
	(0.24)	(1.29)	(1.05)	(0.30)	(1.26)	(0.98)

Table 10
Firm Efficiency and the Likelihood of Segment Acquisition

The table reports estimation results for Probit regressions that examine the effect of firm characteristics on the likelihood of segment acquisition for the sample of 151 segment-years over the 1978-2000 period. The sample contains only observations for segments in the year of their addition for which data on their firms' efficiencies in the previous two years are available. The estimated coefficients are from regression specifications of the following model (3):

$$ADDTYPE_{jit} = \lambda_0 + \lambda_1\ EFFICIENCY_{it} + \lambda_2\ EFFICIENCY_{it-1} + \lambda_3\ EFFICIENCY_{it-2} + \lambda_4\ H.\ RELAT_{jit} + \lambda_5\ V.\ RELAT_{jit} + \lambda_6\ FIRM\ SIZE_{it} + \lambda_7\ LEVERAGE_{it} + \varepsilon_{jit}.$$

where the dependent variable, *ADDTYPE*, is a binary variable set equal to one if the segment is acquired and set equal to zero if the segment is grown internally. The firm efficiency measure is bounded between zero and one, where one (zero) indicates a fully efficient (inefficient) firm. Detailed definitions of these and other variables are available in Table 1. All model specifications include industry (defined at the segment's two-digit SIC level) and year fixed effects. T-statistics are reported in parentheses. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively. Goodness of fit is measured using McFadden's pseudo-R^2, which is estimated as $1-(\log L_1/\log L_0)$, where L_1 is the maximum value of the likelihood function for the estimated model and L_0 is the maximum value of the likelihood function for the model evaluated with the constant term, λ_0, only (see Maddala 1983, p. 40).

	Model Specification	
Variable	**(1)**	**(2)**
Intercept	-52.368	-59.821
	(0.00)	(0.00)
FIRM EFFICIENCY	1.325	1.223
	(0.56)	(0.47)
FIRM EFFICIENCY $_{t-1}$	6.447 **	8.360 **
	(2.31)	(2.44)
FIRM EFFICIENCY $_{t-2}$	4.134	4.418
	(1.33)	(1.24)
H.RELAT DUMMY		1.731 *
		(1.80)
V.RELAT DUMMY		0.657
		(1.03)
FIRM SIZE	0.764 ***	0.886 ***
	(4.01)	(4.05)
LEVERAGE	1.337	0.804
	(1.13)	(0.59)
Pseudo-R^2	0.552	0.587

Table 11
Efficiency and the Likelihood of Divestiture

The table reports estimation results for the relation between segment efficiency and the likelihood of segment divestiture for the sample of 29,355 segment-years over the 1976-1998 period. The sample contains only observations for segments in the four-year period prior to their divestitures, if any. The estimated coefficients are from Probit regressions given by the following equation (4):

$$DIVESTITURE_{jit+1} = \gamma_0 + \gamma_1\ EFFICIENCY_{jit} + \gamma_2\ FIN.\ NEED_{it} + \gamma_3\ INFO.\ ASYMMETRY_{it} + \gamma_4\ SEGMENT\ SIZE_{jit} + \gamma_5\ FIRM\ SIZE_{it} + \gamma_6\ IND.\ GROWTH_{jt} + \varepsilon_{jit}.$$

The dependent variable, *DIVESTITURE*, is a binary variable set equal to one if the segment is divested and equal to zero otherwise. *FIN. NEED* represents a measure of a firm's financial need, proxied by firm leverage, *LEVERAGE*, and operating return on sales, *ROS*. *INFO. ASYMMETRY* represents a measure of asymmetric information associated with a firm, proxied by analysts' earnings forecast error, *ERROR*, forecast dispersion, *DISPERSION*, and the number of analysts following the firm, *N ANALYSTS*. Detailed definitions of these and other variables are available in Table 1. All model specifications include industry (defined at the segment's two-digit SIC level) and year fixed effects. T-statistics are reported in parentheses. The symbols *, ** and *** indicate statistical significance at less than the 10-percent, 5-percent, and 1-percent levels, respectively. Goodness of fit is measured using McFadden's pseudo-R^2, which is estimated as 1–(log L_1/log L_0), where L_1 is the maximum value of the likelihood function for the estimated model and L_0 is the maximum value of the likelihood function for the model evaluated with the constant term, γ_0, only (see Maddala 1983, p. 40).

	Model Specification							
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Intercept	-1.992 ***	-1.945 ***	-1.499 ***	-2.171 ***	-2.096 ***	-2.163 ***	-1.295 ***	-0.959 **
	(5.97)	(5.87)	(3.51)	(6.55)	(6.36)	(5.37)	(2.90)	(2.10)
EFFICIENCY	0.292 **	0.288 **	0.293 **	0.290 **	0.283 **	0.285 **	0.287 **	0.576 ***
	(2.05)	(2.03)	(2.06)	(2.05)	(2.00)	(2.02)	(2.02)	(3.40)
LEVERAGE	0.543 ***	0.558 ***	0.663 ***				0.666 ***	0.668 ***
	(4.54)	(4.68)	(5.32)				(5.32)	(5.33)
ROS				0.040	0.041	0.016		
				(0.28)	(0.30)	(0.17)		
ERROR	0.545			0.950 ***				
	(1.55)			(2.88)				
DISPERSION		0.588			1.208 **			
		(1.07)			(2.39)			
N. ANALYSTS			0.006 *			-0.001	0.008 *	0.007 *
			(1.65)			(0.26)	(1.92)	(1.82)

Table 11(continued)
Efficiency and the Likelihood of Divestiture

Variable	Model Specification							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SEGMENT SIZE	-0.300 ***	-0.300 ***	-0.301 ***	-0.296 ***	-0.296 ***	-0.297 ***	-0.304 ***	-0.301 ***
	(13.30)	(13.29)	(13.34)	(13.22)	(13.21)	(13.28)	(13.42)	(13.23)
FIRM SIZE	-0.001	-0.003	-0.028	0.013	0.010	0.014	-0.043 **	-0.045 **
	(0.10)	(0.22)	(1.41)	(1.00)	(0.79)	(0.79)	(1.99)	(2.08)
IND. GROWTH	0.390 **	0.390 **	0.394 **	0.390 **	0.389 **	0.388 **	0.383 **	0.380 **
	(2.03)	(2.02)	(2.04)	(2.03)	(2.02)	(2.02)	(1.98)	(1.96)
HERF							0.127	0.135
							(1.23)	(1.30)
H.RELAT DUMMY							-0.108 *	-0.116 **
							(1.87)	(1.99)
V.RELAT DUMMY							0.174 **	0.169 **
							(2.39)	(2.31)
FIRM EFFICIENCY								-0.619 ***
								(3.30)
Pseudo-R^2	0.108	0.108	0.108	0.104	0.103	0.102	0.110	0.112

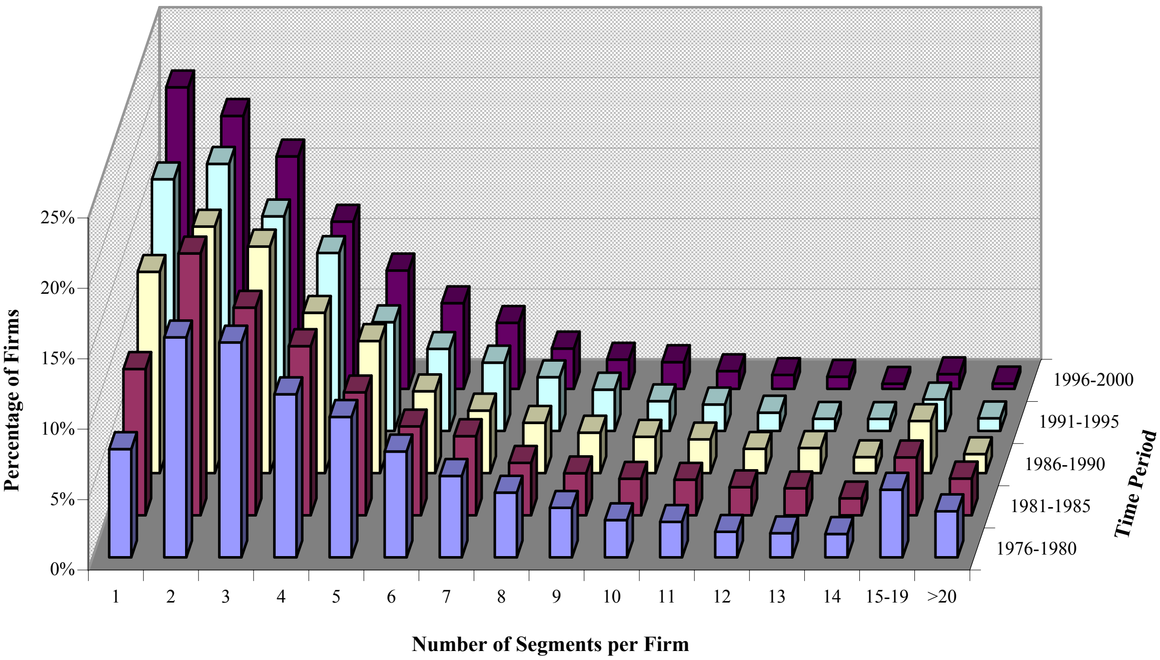

Figure 1. Distribution of Firms across Number of Segments and Time Period

The figure shows frequency distribution of proportions of firm-years across number of segments and time period. The sample consists of 32,057 firm-years that represent 3,737 firms during the 1976-2000 period. Segments are defined at the two-digit SIC level.